整理番号　２８３９１０７　　発送番号　３６３８７３　12.12.19
発送日　平成１２年１２月１５日　　1／　2

拒絶理由通知書

特許出願の番号	平成　６年　特許願　第３４０２６４号
起案日	平成１２年１２月１１日
特許庁審査官	桐畑　幸▲廣▼　　９６０６　２Ｐ００
特許出願人代理人	谷　義一　　（外　１名）様
適用条文	第２９条第２項

この出願は、次の理由によって拒絶をすべきものである。これについて意見があれば、この通知書の発送の日から６０日以内に意見書を提出して下さい。

理　由

本願の下記の請求項に係る発明は、下記引用例に記載された発明に基づいて、当業者が容易に発明をすることができたものであるから、特許法第２９条第２項の規定により特許を受けることができない。

記

・請求項　１～８
・引用例　1．特公昭６２－４６３５８号公報
　　2．特開平３－２５６７４９号公報
　　3．特開昭６１－１４６５５６号公報
・備考
上記引用例１には、１の吐出口に対応して複数のエネルギー発生素子を有するインクジェット記録装置が記載されている。
また、上記引用例２又は３には、予備吐出時のインク吐出量を印字時のインク吐出量より大きくする技術が記載されており、引用例１に記載された発明に、引用例２又は３に記載された上記技術を適用して、本願の上記請求項に係る発明の

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続　　葉

ように構成することは、当業者が容易に想到し得ることであり、その効果も当業者が予測し得る程度のものである。

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審査第二部印刷・プリンター　桐畑　幸廣
TEL 03(3581)1101　　内線3202,3203
FAX 03(3580)6903

先行技術文献調査結果の記録

・調査した分野　　ＩＰＣ第７版　Ｂ４１Ｊ　２／１７５
　　Ｂ４１Ｊ　２／２０５

この先行技術文献調査結果の記録は、拒絶理由を構成するものではない。

(A)

(Translation)

Case No.: 2839107 Mailing Number: 363873
Mailing Date: December 15, 2000

OFFICIAL NOTICE OF REJECTION

Patent Application No. 340,264/1994

Date of Draft: December 11, 2000

Examiner, The Patent Office: Y. Kirihata 9606 2P00

Agent for Applicant: Yoshikazu Tani, Esq. (and one other)

Applied Provision(s): Section 29, Paragraph 2

The present application is rejected for the following reasons. The applicant may present an argument, if any, within 60 days from the mailing date of this Official Notice.

REASONS

The invention(s) of the present application as claimed in claim(s) set forth below could have been obvious to one skilled in the art, to which the invention(s) pertains(s), on the basis of the publication(s) as indicated below as distributed in Japan or foreign countries prior to the filing date of the present application. Therefore, the present invention(s) is(are) unpatentable under the provision of Section 29, Paragraph 2 of the Patent Law.

Note

Claims 1 to 8

References:

1. Japanese Patent Application Publication No. Sho 62-46358

2. Japanese Patent Application Laid-open No. Hei 3-256749

3. Japanese Patent Application Laid-open No. Sho 61-146556

Remarks:

Reference 1 discloses an ink-jet printing apparatus having a plurality of energy producing elements corresponding to one ejection port.

References 2 or 3 discloses a technique in which the amount of ink ejection at a preliminary ejecting operation is made larger than the amount of ink ejection at a time of printing operation. It would have been obvious for one skilled in the art to reach claims 1 to 8 by applying the technique of reference 2 or 3 to the invention of reference 1. Moreover, the advantageous effect is of a mere level that could have been expected.

Record of Search Results of Prior Art Literature

Technical Field Searched:

IPC 7th edition B41J 2/175, B41J 2/205

This record of search results of prior art literature does not constitute reason for rejection.

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Group Art unit: 2853

Examiner: S. Johnson, Jr.

Applicants	:	**Noribumi KOITABASHI et al.**	)
Application No.:		**08/579,241**	) TRANSLATION OF PRIORITY DOCUMENTS DECLARATION IN SUPPORT THEREOF
Filed	:	**December 28, 1995**	)
For	:	**INK-JET APPARATUS EMPLOYING INK-JET HEAD HAVING A PLURALITY OF INK EJECTION HEATERS CORRESPONDING TO EACH INK EJECTION OPENING**	)

Assistant Commissioner for Patents
Washington, D.C. 20231

Sir:

I, Atsuko SEKIGUCHI, of Tani & Abe Patent Office, No. 6-20, Akasaka 2-chome, Minato-ku, Tokyo 107-0052, Japan, declare that:

1. I know well both the Japanese and English languages.

2. I translated Japanese Patent Application No. 340264/1994 of December 29, 1994 from the Japanese language to the English language, a copy of the translation being attached hereto.

3. The attached English translation of the Japanese application identified in paragraph 2 above is a true and correct translation to the best of my knowledge and belief.

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code, and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

Signed this July 17, 2000

Atsuko Sekiguchi

Atsuko SEKIGUCHI

続　　葉

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特許出願人代理人	谷　義一　　（外　１名）様
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・請求項　１～８
・引用例　１．特公昭６２－４６３５８号公報
　　２．特開平３－２５６７４９号公報
　　３．特開昭６１－１４６５５６号公報
・備考
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続葉有

PATENT OFFICE
JAPANESE GOVERNMENT

This is to certify that the annexed is a true copy of the following application as filed with this Office.

Date of Application: December 29, 1994

Application Number: Japanese Patent Application No. 340264/1996

Applicant(s): CANON KABUSHIKI KAISHA

January 26, 1996

Commissioner,
Patent Office Yuji KIYOKAWA

Certificate No. 3085348/1995

(Translation)
340264/1994

Applicant's Case Number: 2839107 (1/2)

(Document's Name) Patent Application

(Case Number) 2839107

(Filing Date) December 29, 1994

To: Commissioner, the Patent Office

(International Patent Classification) B41J 2/01

(Title of the Invention)

AN INK-JET APPARATUS

(Number of claims) 8

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(Indication of Official fee)

(Method of Payment)	Pre-payment
(Account Number of Payment)	013424
(Amount)	¥21,000.-

(List of the filing documents)

Specification	1 copy
Formal Drawings	1 copy
Abstract	1 copy
General Authorization Number	9004548

(Necessity of Proof) Yes

[DOCUMENT NAME] SPECIFICATION

[TITLE OF THE INVENTION]

An Ink-Jet Apparatus

[SCOPE OF CLAIM FOR A PATENT]

[Claim 1]

An ink-jet apparatus in which printing is performed by ejecting ink from an ink-jet head toward a medium by the use of the ink-jet head capable of ejection in a plurality of ink ejection amount modes, the ink-jet apparatus comprising:

printing means for performing the printing in a smaller ink ejection amount mode out of the plurality of ink ejection amount modes; and

preliminary ejecting means for performing ink ejection irrelevant to the printing from the ink-jet head in an ink ejection amount mode larger than the smaller ink ejection amount mode out of the plurality of ink ejection amount modes during the printing by the printing means.

[Claim 2]

An ink-jet apparatus in which printing is performed by ejecting ink to a medium with energy generated by energy generating elements by the use of an ink-jet head having a plurality of energy generating elements per ejection opening, the ink-jet apparatus comprising:

printing means for performing printing in each of a plurality of ejection amount modes set by combinations of energy generating elements to be used out of the plurality of energy generating elements; and

preliminary ejecting means for performing ink ejection irrelevant to printing from the ink-jet head during the printing in any one of the plurality of ejection amount modes by the printing means, in an ejection amount mode larger than or equal to that of the ejection amount mode in which the printing is performed.

[Claim 3]

An ink-jet apparatus as claimed in claim 2, wherein the plurality of energy generating elements are different from each other in magnitude of the energy to be generated.

[Claim 4]

An ink-jet apparatus characterized in that the plurality of energy generating elements are the same as each other in magnitude of the energy to be generated, and the ejection amount mode is varied according to the number of energy generating elements to be used.

[Claim 5]

An ink-jet apparatus as claimed in claim 4, wherein, in printing in an ejection mode in which all

of the plurality of energy generating elements are not used, the preliminary ejecting means performs ink ejection by using the number of energy generating elements greater by one than that used in the printing.

[Claim 6]

An ink-jet apparatus in which printing is performed by ejecting ink to a medium with energy generated by energy generating elements by the use of an ink-jet head having a plurality of energy generating elements per ejection opening, the ink-jet apparatus comprising:

printing means for performing printing in each of a plurality of ejection amount modes set by combinations of energy generating elements to be used out of the plurality of energy generating elements,

preliminary ejection modes being set in such a manner as to correspond to the plurality of ejection amount modes, respectively.

[Claim 7]

An ink-jet apparatus as claimed in claim 6, wherein there is further provided a preliminary ejection mode in switching the ejection amount modes.

[Claim 8]

An ink-jet apparatus as claimed in any one of claims 1 to 7, wherein the energy generating element generates thermal energy, which then generates bubbles in the ink, thereby ejecting the ink.

[DETAILED DESCRIPTION OF THE INVENTION]

[0001]

[Field of Industrial Utilization]

The present invention relates to an ink-jet apparatus. More specifically, the invention relates to an ink-jet apparatus using an ink-jet head having a plurality of ejecting heaters on an ink path corresponding to each of ink ejection openings.

[0002]

[Prior Art]

An ink-jet apparatus has been mainly known as a printing apparatus in printers, copy machines and the like. Among various ink-jet apparatus, there has become recently widespread an ink-jet printing apparatus of the type in which thermal energy is used as energy for ink ejection, for ejecting ink with bubbles generated by the thermal energy. In addition, as other applications of this type of ink-jet printing apparatus has become known in recent years an ink-jet textile printing apparatus for printing a given pattern, a picture, a synthesized image or the like on cloth.

[0003]

An ink-jet head for use in such an ink-jet printing apparatus as described above has an electrothermal transducer element (hereinafter also referred to as "a heater") as a source for generating

thermal energy. In most cases, the ink-jet head is provided with one heater corresponding to one ejection opening. In contrast, there has been known an ink-jet head using a plurality of heaters in each of ink ejection openings for the reasons discussed below.

[0004]

First, it has been known to alternately or selectively drive a plurality of heaters for the purpose of extension of the life of the ink-jet head. Second, a plurality of heaters are used for widening the range of variations in ink ejection amount, wherein the ink ejection amount is varied by selecting heaters to be driven or the number of heaters to be driven.

[0005]

In the latter case, in a more specific structure, a plurality of heaters are arranged along an ink ejecting direction on an ink path communicating with the ejection opening in the ink-jet head, so that a distance between the ejection opening and the heaters to be driven is varied by selecting the heaters to be driven (namely, the heaters to be made to generate heat) or the number of heaters to be driven, thus varying the ejection amount of the ink.

[0006]

Another structure of the ink-jet head has been known in which a plurality of heaters different in

surface area are arranged on an ink path, to make an ink ejection amount variable by varying the heaters to be driven or the number of heaters to be driven.

[0007]

[Problems to be Solved by the Invention]

However, when printing is performed by using the ink-jet head having the plurality of heaters corresponding to each of the ejection openings, as described above, there may arise a problem of so-called preliminary ejection which is performed in one step of ejection recovery processes.

[0008]

More specifically, the preliminary ejection is generally to perform ink ejection irrespective of printing from the ink-jet head at a predetermined position in the printing apparatus, thereby removing ink of increased viscosity in the ink-jet head to maintain a good ink ejecting condition. Such preliminary ejection is generally performed immediately after turning-on of a power supply or at given time intervals during printing. However, in the case where ink ejection can be performed in various ejection amounts by a plurality of heaters as described above, printing may be performed in a small ejection amount. During such printing operation, when the preliminary ejection is performed in the small ink ejection amount, the effect of the preliminary

ejection depends upon the ejection amount. For instance, the amounts of the ink of the increased viscosity and bubbles to be discharged out of the ink-jet head become smaller accordingly. Also, it can be said that since the ejection amount and ejection speed during the printing is small, the viscosity of the ink is liable to be increased. Therefore, the interval of the preliminary ejection need be shortened, thereby lowering a throughput of the printing.

[0009]

The present invention has been accomplished in an attempt to solve the above-described problems. Therefore, an object of the present invention is to provide an ink-jet printing apparatus which can perform appropriate preliminary ejection in each ejection amount mode set by a heater to be used out of a plurality of heaters.

[0010]

[Means for Solving the Problems]

According to the present invention, an ink-jet apparatus in which printing is performed by ejecting ink from an ink-jet head toward a medium by the use of the ink-jet head capable of ejection in a plurality of ink ejection amount modes, comprises: printing means for performing the printing in a smaller ink ejection amount mode out of the plurality of ink ejection amount modes; and preliminary ejecting means for

performing ink ejection irrelevant to the printing from the ink-jet head in an ink ejection amount mode larger than the smaller ink ejection amount mode out of the plurality of ink ejection amount modes during the printing by the printing means.

[0011]

Furthermore, an ink-jet apparatus in which printing is performed by ejecting ink to a medium with energy generated by energy generating elements by the use of an ink-jet head having a plurality of energy generating elements per ejection opening, comprises: printing means for performing printing in each of a plurality of ejection amount modes set by combinations of energy generating elements to be used out of the plurality of energy generating elements; and preliminary ejecting means for performing ink ejection irrelevant to printing from the ink-jet head during the printing in any one of the plurality of ejection amount modes by the printing means, in an ejection amount mode larger than or equal to that of the ejection amount mode in which the printing is performed.

[0012]

Moreover, an ink-jet apparatus in which printing is performed by ejecting ink to a medium with energy generated by energy generating elements by the use of an ink-jet head having a plurality of energy

generating elements per ejection opening, comprises printing means for performing printing in each of a plurality of ejection amount modes set by combinations of energy generating elements to be used out of the plurality of energy generating elements, wherein preliminary ejection modes are set in such a manner as to correspond to the plurality of ejection amount modes, respectively.

[0013]

[Function]

Since with the above-described configuration the preliminary ejection can be performed in a greater ejection amount when the preliminary ejection is performed during the printing in a smaller ejection amount, the preliminary ejection can be performed more effectively than in a small ejection amount.

[0014]

[Preferred Embodiments]

Preferred embodiments according to the present invention will be discussed hereinafter in detail with reference to the accompanying drawings.

[0015]

Fig. 1 is a perspective view showing a printer as an ink-jet printing apparatus according to the present invention.

[0016]

In Fig. 1, reference numeral 101 denotes a printer, reference numeral 102 denotes an operation panel provided at the upper front portion of a housing of the printer 101, reference numeral 103 denotes a sheet feeding cassette to be inserted into an opening at the front face of the housing, reference numeral 104 denotes a sheet (recording medium) to be fed from the sheet feeding cassette 103, and reference numeral 105 denotes a discharged sheet tray for holding sheets discharged via a sheet feeding path inside the printer 101. Reference numeral 106 denotes a main body cover in an L-shaped cross section. The main body cover 106 is designed for covering an opening 107 formed at the right front portion of the housing , and is pivotally mounted at the inner end of the opening 107 by means of a hinge 108. In addition, within the housing, a carriage 110 supported by a guide or the like (not shown) is arranged. The carriage 110 is provided in such a manner as to movably reciprocate in a width direction of the sheet to be fed on the sheet feeding path (hereinafter also referred to as " a primary scanning direction").

[0017]

The carriage 110 in the present embodiment generally comprises a stage 110a to be held horizontally by the guide or the like, an opening (not

shown) for accommodating ink-jet head s at a rear portion on the stage 110a, a cartridge garage 110b for receiving ink-jet heads 3Y, 3M, 3C and 3Bk which are detachably loaded on the stage 110a in front of the opening, and a cartridge holder 110c opened and closed relative to the garage 110b so as to prevent any detachment of a cartridge received within the garage 110b.

[0018]

The stage 110a is slidably supported at the rear end thereof by means of a guide, and further, slidably engages with a not-shown guide plate at the lower portion of the front end thereof. The guide plate may serve as a sheet holding member for preventing the sheet fed via the sheet feeding path from floating, or may have a function of lifting up the stage relative to the guide in a cantilever fashion according to the thickness of the sheet.

[0019]

In the opening of the stage 110a is loaded the ink-jet head (not shown) with ink ejecting openings directed downward.

[0020]

The cartridge garage 110b is provided with a through opening extending in a lengthwise direction, for simultaneously receiving the four ink-cartridges 3Y, 3M, 3C and 3Bk. On the both sides of the outer

surfaces of the cartridge garage 110b are formed engaged recesses to be engaged with engaging claws of the cartridge holder 110c.

[0021]

At the front end of the stage 110a, the cartridge holder 10c is pivotally mounted via a hinge 116. The dimension from the front end of the garage 110b to the hinge 116 is determined in consideration of a projecting dimension from the cartridges 3Y, 3M, 3C and 3Bk from the front end of the garage 110b when the cartridges 3Y, 3M, 3C and 3Bk are received inside the garage 110b. The cartridge holder 110c is formed into a substantially rectangular plate. On the cartridge holder 110c, a pair of engaging claws 110e project in a direction perpendicular to the plate surface on both sides of the upper portion away from the lower portion fixed via the hinge 116, and engage with engaged recesses 110d formed at the garage 110b when the holder 110c is closed. An insertion hole 120, to which the respective handles of the cartridges 3Y, 3M, 3C and 3Bk are inserted, is formed in the plate of the holder 110c. The insertion hole 120 is formed into a corresponding shape at a corresponding position in a corresponding size to the handles.

[0022]

Fig. 2 is a block diagram illustrating an example of the arrangement of a control system in the ink-jet printing apparatus.

[0023]

Here, reference numeral 200 denotes a controller constituting a main control unit, which includes a CPU 201 in a form of, for example, a microcomputer for executing various modes , described later, a ROM 203 storing therein fixed data such as programs, tables, voltage values of a heat pulse and pulse widths, and a RAM 205 provided with a region for developing image data and a region for working. Reference numeral 210 denotes a host system (or a reader unit for reading an image) serving as a supply source of the image data. The image data , other commands, status signal s and the like are transmitted to or received from the controller via an interface (I/F) 212.

[0024]

The operation panel 102 is provided with a switch group which receives commands input by an operator and includes a mode selector switch 220 for selecting various modes, a power source switch 222, a print switch 224 for designating starting of printing, an ejection recovering switch 226 for designating initiation of ejection recovering process es, and the like, as described later. Reference numeral 230

denotes a sensor group which detect s the condition of the apparatus and includes a sensor 232 for detecting positions of the carriage 110 (see Fig. 1) such as a home position and a start position, and a sensor 234 to be used for detecting a pump position including a leaf switch.

[0025]

Reference numeral 240 denotes a head driver for driving an electrothermal transduc er element of the ink-jet head in accordance with printing data and the like. A part of the head driver also may be used for driving temperature heater s 30A and 30B. Furthermore, temperature detecti on values are input to the controller 200 from temperature sensors 20A and 20B. Reference numeral 250 denotes a primary scanning motor for shifting the carriage 110 in a primary scanning direction, and reference numeral 252 denotes a driver for the motor 250. Reference numeral 260 denotes a n auxiliary scanning motor which is used for feeding the sheet 104 as the recording medium (see Fig. 1).

[0026]

The above-mentioned ink-jet printing apparatus has the ink-jet head cartridge s 2C, 2M, 2Y and 2Bk for inks of four colors, i.e., cyan, magenta, yellow and black, respectively.

[0027]

Fig. 3 is a cross-sectional view showing an ink tank cartridge 3 and an ink-jet head 2 to be used in the above-mentioned ink-jet printing apparatus in a connected state.

[0028]

The ink tank cartridge 3 used in the present embodiment includes two chambers of a vacuum generating member containing chamber 53 filled with ink absorbers 52, and an empty ink containing chamber 56. In the initial condition, ink is filled in both of these chambers. In association with ink ejection and the like in the ink-jet head 2, the ink in the ink containing chamber 56 is first consumed.

[0029]

The ink-jet head 2 has heaters (not shown in Fig. 3) for generating thermal energy to be used for ejection on a plurality of ink paths 2A corresponding to the ink ejection openings, for ejecting the ink supplied from the ink tank cartridge 3 via a connection pipe 4.

[0030]

(First Embodiment)

Fig. 4 is a cross-sectional view schematically showing the structure of the ink-jet head 2 in the first embodiment according to the present invention.

[0031]

As shown in Fig. 4, two heaters SH1 and SH2 are arranged on each of the ink paths 2A in the longitudinal direction. The two heaters are different in surface area from each other, and electrodes are wired (not shown) such that the heaters can be driven independently of each other or simultaneously. It should be noted that the heaters SH1 and SH2 are the same in length in the longitudinal direction of the ink path 2A but are different in width, and therefore, they are different in surface area from each other. At the tip end of the ink path 2A is opened an ejection opening 2N.

[0032]

The structures, which are provided in the predetermined number per ink path and each of which consists of the heaters, the ejection opening and the ink path, are arranged in the ink-jet head 2 in the density of 360 DPI. In the present embodiment, the area of the ejection opening and the area of the heater are the same in each ink path.

[0033]

In the present embodiment, basically, the ink ejection amount can be set at three steps (hereinafter referred to as "basic ejection amount modes") according to the combination of the heaters to be

driven in each of the ejection openings in the case where two heaters are used. Hereinafter, description will be given of the basic ejection amount modes in the present embodiment.

[0034]

Basically, three ejection amount modes, i.e., small, medium and large, can be achieved by switching the heater to be driven. In the small ejection amount mode, only the heater SH1 is driven to eject 15 pl in volume of liquid droplets; in the medium ejection amount mode, only the heater SH2 is driven to eject 25 pl in volume of ink droplets; and in the large ejection amount mode, both of the heaters SH1 and SH2 are driven simultaneously to eject 40 pl (= 15 + 25 pl) of liquid droplets.

[0035]

Next, explanation will be made below on printing modes using the above-mentioned three basic ejection amount modes.

[0036]

(360 DPI mode: normal printing mode)

In this mode, printing is performed in the density of 360 DPI in the large ejection amount mode.

[0037]

In this mode, the preliminary ejection is performed in the large ejection amount mode. More specifically, the preliminary ejection is performed by

driving both of the larger heater SH2 and the smaller heater SH1.

[0038]

(720 DPI mode)

Basically, in the small ejection amount mode, printing is performed in the density of 720 DPI × 720 DPI by shifting the ink-jet head by half a pixel relative to the recording medium. Even in this small ejection amount mode, the ejection amount may be switched to the medium or large amount according to the type of recording medium, thereby appropriately adjusting the density.

[0039]

Since the ink ejection amount is small and the ejection speed is low when the printing is performed only in the small ejection amount mode, a time interval until stable ejection becomes impossible due to an increase in viscosity of ink and intrusion of bubbles caused by evaporation of the ink at the ejection opening if ejection is not carried out for a while can becomes shorter. Therefore, irrespective of the ejection amount mode, the preliminary ejection is performed in the large ejection amount mode.

[0040]

Fig. 5 is a flowchart illustrating a print sequence in the present embodiment. In the present embodiment, printing is performed in the large, medium

or small ejection mode depending upon respective printing modes, as described above.

[0041]

In Fig. 5, immediately after turning-on of the power supply for the apparatus, the preliminary ejection is performed in the large ejection amount mode (step S1). Subsequently, a suction recovery process is performed (step S2). This is because the viscosity of the ink is increased or bubbles are admixed to a relatively great extent during the period when the apparatus is left unused.

[0042]

Next, in step S3, the preliminary ejection is performed in the medium ejection amount mode. Thereafter, the apparatus stands by for a print initiation command in step S4. During the stand-by state, the stand-by period is counted (step S5). When the stand-by period exceeds a predetermined period (step S6), the preliminary ejection in the medium ejection amount mode is performed.

[0043]

When the print initiation command is input (step S4), a currently set printing mode is checked (step S9). For instance, when the above-described 360 DPI mode is set, the printing mode is judged to be the large ejection amount mode. Based on the judgement, the printing is performed by a predetermined amount,

e.g., several lines in the selected one of the small, medium and large ejection amount mode s (step S10, S12 or S14).

[0044]

After the printing is performed by the predetermined amount, the preliminary ejection is performed in the ejection amount modes in the case where the small ejection amount mode is set (step S11); the preliminary ejection is performed in the large ejection amount mode in the case where the medium ejection amount mode is set (step S13); and the preliminary ejection is performed in the large ejection amount in the case where the large ejection amount mode is set (step S15).

[0045]

Thus, the preliminary ejection during the printing operation is performed in the ejection amount mode larger than the ejection amount mode set for the printing, thereby lengthening the interval of the preliminary ejection during printing mode.

[0046]

(Second Embodiment)

Figs. 6(a) and 6(b) are cross-sectional views showing two examples of ink-jet head s which can be used in a second embodiment according to the present invention.

[0047]

In the ink-jet head to be used in the present embodiment, two heaters SH1 and SH2 of the same size are arranged on an ink path 2A or in a direction perpendicular to the ink path 2A.

[0048]

With this heater construction, in the present embodiment, two ejection amount modes can be set as follows: a large ejection amount mode in which a large amount of ink is ejected by driving the two heaters simultaneously; and a small ejection amount mode in which a small amount of ink is ejected by driving either one of the two heaters.

[0049]

Furthermore, printing modes similar to those described in the first embodiment are set.

[0050]

Fig. 7 is a flowchart illustrating a print sequence in the present embodiment.

[0051]

Also in the present embodiment, like the foregoing first embodiment, preliminary ejection is performed in the large ejection amount mode after turning-on of a power supply (step S101). Furthermore, if the ejection amount mode is switched from the large ejection amount mode to the small ejection amount mode during printing (step 105), the preliminary ejection

mode is performed in the large ejection amount at the timing of switching (step 106). Thereafter, a timer 1 for printing in the small ejection amount mode is reset (step 107).

[0052]

Furthermore, in the present embodiment, the preliminary ejection is not performed every printing by a predetermined amount, but the interval of the preliminary ejection is managed by respective timers for the ejection amount modes. Here, the interval of the preliminary ejection of the printing in the small ejection amount mode (timer 1) is set to be shorter than that of the preliminary ejection of the printing in the large ejection amount mode (timer 2). However, since the preliminary ejection is performed in the large ejection amount mode, the interval can be set longer than the interval which is allowed in the case of the preliminary ejection in the small ejection amount mode.

[0053]

In place of a resetting process of the timer 1 in step S107, a remaining period (timer 2) of the printing in the large ejection amount mode may be converted into a remaining period (timer 1) of the printing in the small ejection amount mode.

[0054]

(Third Embodiment)

A third embodiment is similar to the foregoing second embodiment in the construction of the ink-jet head except that the size of each of heaters SH1 and SH2 is increased to secure an ejection amount enough to achieve printing in the density of 360 DPI by driving either one of the heaters.

[0055]

More specifically, only one of the two heaters is driven and the heater to be driven is appropriately switched so as to extend the life of the heater.

[0056]

Even with the above-described construction, the preliminary ejection is performed by using the two heaters.

[0057]

(Fourth Embodiment)

Fig. 8 is a cross-sectional view showing the construction of an ink-jet head in a fourth embodiment according to the present invention .

[0058]

The ink-jet head in the present embodiment has three heaters SH1, SH2 and SH3 within an ink path 2A and permits three ejection amount modes to be set depending upon the number of heaters to be driven.

[0059]

In a large ejection amount mode, the three heaters are driven. However, in this mode, since an ink ejection amount becomes very large, a driving frequency is controlled to be lower than th ose in other two ejection amount modes . Therefore, a printing speed is slightly lowered.

[0060]

On the other hand, in a small ejection amount mode, only one of the heaters is driven. However, the two heaters are driven for the preliminary ejection during printing. Here, the reason why all of the three heaters are not driven is that the driving frequency cannot be increased while large power for the ejection may be attained by driving the three heaters, and therefore, a relatively long period is required for the preliminary ejection , to thus substantially lower the printing speed.

[0061]

Furthermore, while the present invention has been applied to the system for ejecting the ink by the effect of the bubbles generated by the thermal energy by the use of the heaters in the above-described embodiments, the application of the present invention should not be limited to the above-described system. For instance, the present invention is, of course,

applicable to an ink-jet apparatus of the structure having a plurality of piezo electric elements.

[0062]

(Others)

According to the present invention, particularly among the ink-jet recording systems, the excellent effects can be produced in the recording head or apparatus of the system provided with the means for generating thermal energy (e.g., an electrothermal transducer, a laser beam or the like) as energy utilized for performing the ink ejection so as to induce the ink state variation caused by the thermal energy, thus achieving high density and high fineness of recording.

[0063]

It is preferable that the basic principle disclosed in, e.g., U.S. Patent No. 4,723,129 or 4,740,796 should be used for the typical configuration and principle of the above-described apparatus. This system can be applicable to either an on-demand type or a continuous type. Particularly, the on-demand type is effective because at least one drive signal for rapidly increasing a temperature in excess of a film boiling point in response to recording information is applied to the electrothermal transducer arranged in a manner corresponding to a sheet holding liquid (ink) thereon or a liquid path,

thereby generating thermal energy in the electrothermal transducer so as to generate film boiling at a heat acting surface of the recording head, resulting in formation of bubbles in the liquid (ink) in one-to-one correspondence to the drive signal. Growth or contraction of the bubbles causes the liquid (ink) to be ejected through the ejection opening, thus forming at least one droplet. The drive signal in the form of a pulse is much preferable because the bubbles can grow or be contracted instantaneously and appropriately, and thus, the liquid (ink) can be ejected with remarkably high responsiveness. A signal disclosed in U.S. Patent No. 4,463,359 or 4,345,262 may be suitable for the drive signal in the form of a pulse. More excellent recording can be achieved by using conditions disclosed in U.S. Patent No. 4,313,124 relating to a temperature increasing rate at the heat acting surface.

[0064]

The configurations of the recording heads according to the present invention include the configuration disclosed in U.S. Patent No. 4,558,333 or 4,459,600 in which the heat acting surface is located in a bent region beside the configuration in which the ejection openings, the liquid paths and the electrothermal transducers are combined with each other (a linear liquid channel or a rectangular liquid

channel) as disclosed in the aforementioned specifications. Additionally, the effect according to the present invention may be produced in the configuration disclosed in Japanese Patent Application Laid-open No. 123,670/1984 in which slots common to a plurality of electrothermal transducers are used as ejection openings of the electrothermal transducers, or in the configuration disclosed in Japanese Patent Application Laid-open No. 138,461/1984 in which openings for absorbing a pressure wave of thermal energy correspond to ejection openings. That is, recording operation may be securely performed with efficiency according to the present invention irrespective of whatever the configuration of the recording head is.

[0065]

Furthermore, the recording head of a full-line type having a length corresponding to the maximum width of the recording medium which can be recorded by the recording apparatus may take either one of the configuration in which a plurality of recording heads are combined to cover the length and the configuration of one recording head formed integrally.

[0066]

Additionally, there may be used not only the recording head of the cartridge type in which an ink tank is disposed integrally with the recording head

per se, as described in the above embodiment, but also a recording head of a replaceable chip type in which the head is fixed to the apparatus body to be electrically connected to the apparatus body or ink can be supplied from the apparatus body.

[0067]

It is preferable that ejection recovering means, preliminarily auxiliary means or the like for the recording head should be additionally disposed as constituents of the recording apparatus according to the present invention, thus further stabilizing the advantageous results of the present invention. There are specifically listed capping means with respect to the recording head, cleaning means, pressurizing or sucking means, preliminarily heating means for performing heating by the use of the thermoelectric transducer, other heating elements, or the combination thereof, and preliminarily ejecting means for performing ejection other than recording.

[0068]

With respect to the kind or number of recording heads to be installed, only one recording head may be provided in a fashion corresponding to monochromatic ink, or a plurality of recording heads may be provided in a fashion corresponding to a plurality of inks different in color or concentration. That is, the present invention can be effectively applicable to

recording apparatuses in not only a recording mode in only one main color such as black but also a full-color recording mode in different or mixed colors by using either an integral ink-jet head or a plurality of recording heads in combination.

[0069]

Although the ink in the state of liquid has been explained in the above-described embodiments according to the present invention, there may be used ink which is solidified at room temperature or lower and softened or liquefied at room temperature. Otherwise, since in the ink-jet system, the temperature of the ink is generally controlled so as to keep the viscosity of the ink within a stable ejection range by adjusting the temperature of the ink per se within the range from 30 °C to 70 °C, there may be used ink which becomes liquefied at the time of application of a used recording signal. Additionally, ink which is solid in a left state while is liquefied by heating may be used in order to aggressively prevent an increase in temperature due to thermal energy which is used as energy for transforming the ink from solid to liquid, or to prevent any evaporation of the ink. Anyway, the present invention is applicable to the case using ink having a property which is first liquefied with application of thermal energy, such as ink which is liquefied with application of thermal energy in

response to a print signal to be ejected in a liquid state, ink which has started to be solidified already at the time when it reaches a medium to be printed, or the like. As disclosed in Japanese Patent Application Laid-open No. 56847/1979 or 71260/1985, such ink may be disposed opposite to the thermoelectric transducer in a manner held in a liquid or solid state in a recess or through hole formed at a porous sheet. According to the present invention, the above-described film boiling system is most effective for each of the above-described inks.

[0070]

Furthermore, the ink-jet recording apparatus according to the present invention may be used as an image output terminal for information processing equipment such as a computer, a copy machine combined with a reader, a facsimile apparatus having a transmitting/receiving function, or the like.

[0071]

[Advantageous Results of the Invention]

As is clear from the above description, since according to the present invention the preliminary ejection can be performed in the greater ejection amount mode when the preliminary ejection is performed during the printing in the smaller ejection amount mode, the preliminary ejection can be performed more effectively than in the small ejection amount mode.

[0072]

Consequently, it is possible to prevent any decrease in throughput of the printing caused by the preliminary ejection.

[BRIEF DESCRIPTION OF THE DRAWINGS]

[Fig. 1]

Fig. 1 is a perspective view showing an ink-jet printing apparatus in a first embodiment according to the present invention .

[Fig. 2]

Fig. 2 is a block diagram illustrating mainly a control system of the printing apparatus .

[Fig. 3]

Fig. 3 is a cross-sectional view showing an ink-jet head and an ink tank cartridge for use in the apparatus .

[Fig. 4]

Fig. 4 is a cross-sectional view showing the structure of the ink-jet head in the first embodiment according to the present invention .

[Fig. 5]

Fig. 5 is a flowchart illustrating a printing sequence in the first embodiment .

[Fig. 6]

Figs. 6(a) and 6(b) are cross-sectional views showing two examples of the structure of the ink-jet

head which can be used in a second embodiment according to the present invention.

[Fig. 7]

Fig. 7 is a flowchart illustrating a printing sequence in a third embodiment according to the present invention.

[Fig. 8]

Fig. 8 is a cross-sectional view showing the structure of an ink-jet head in a fourth embodiment according to the present invention.

[REFERENCE NUMERALS]

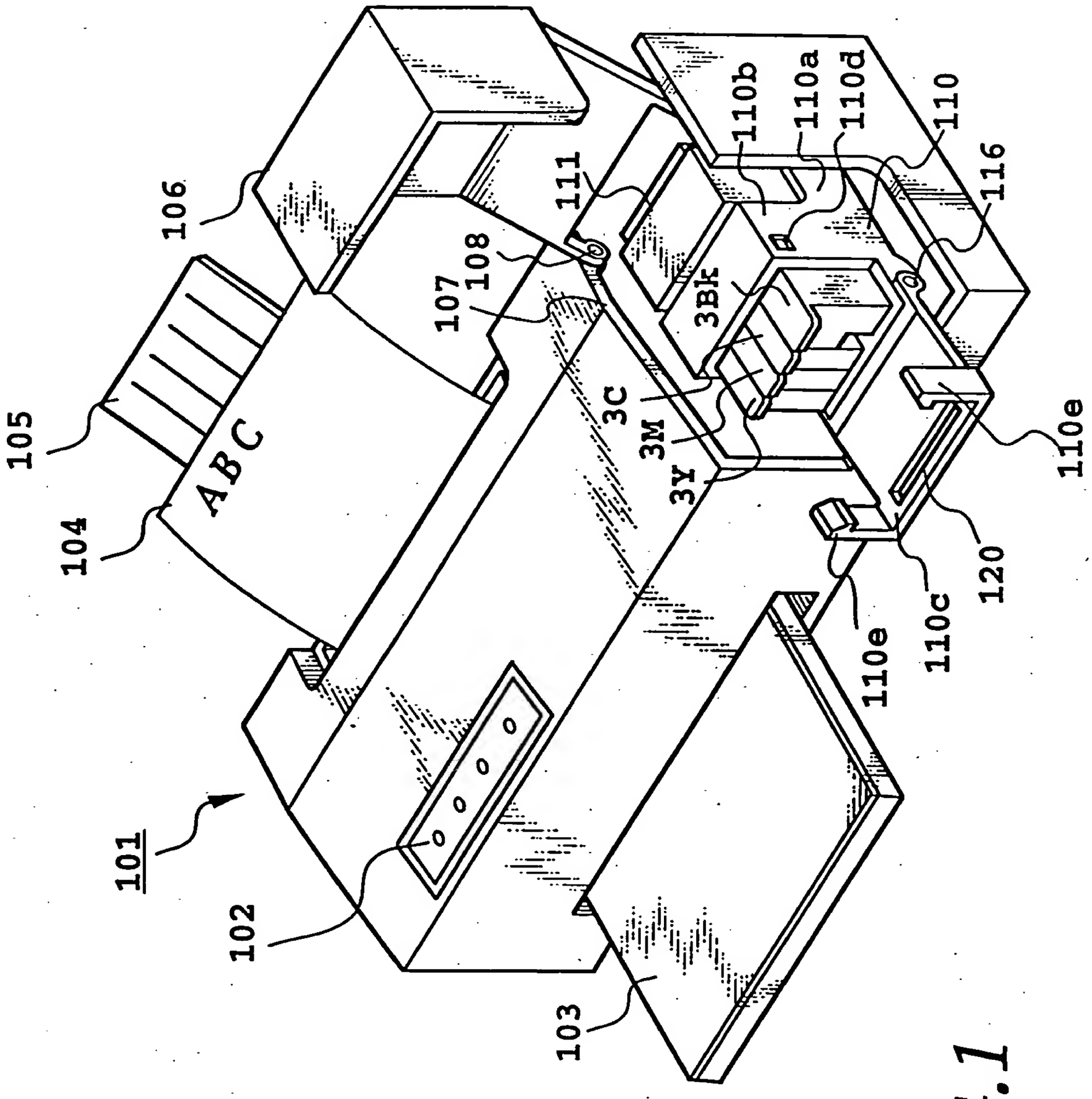
2, 2Y, 2M, 2C, 2Bk ... ink-jet head

2A ... ink path

2N ... ejection opening

200 ... controller

SH1, SH2, SH3 ... heater


106
105
104
ABC
107
108
111
110b
110a
110d
110
116
3BK
3C
3M
3Y
110e
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120
110e
101
102
103

FIG.1

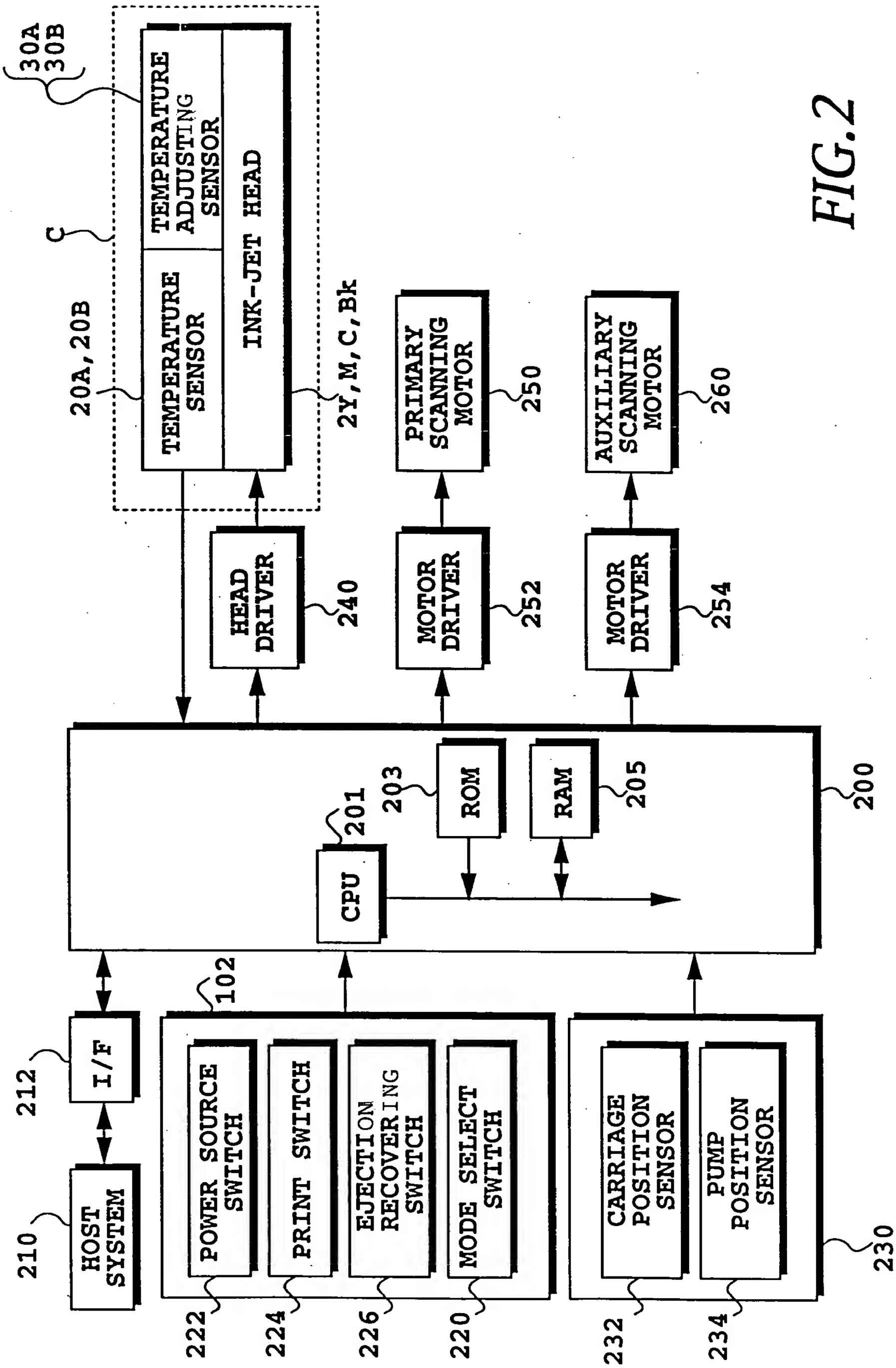
30A
30B
C
20A,20B
TEMPERATURE ADJUSTING SENSOR
TEMPERATURE SENSOR
INK-JET HEAD
2Y,M,C,Bk
PRIMARY SCANNING MOTOR
250
AUXILIARY SCANNING MOTOR
260
HEAD DRIVER
240
MOTOR DRIVER
252
MOTOR DRIVER
254
CPU
201
ROM
203
RAM
205
200
102
I/F
212
HOST SYSTEM
210
POWER SOURCE SWITCH
PRINT SWITCH
EJECTION RECOVERING SWITCH
MODE SELECT SWITCH
222
224
226
220
CARRIAGE POSITION SENSOR
PUMP POSITION SENSOR
232
234
230

FIG.2

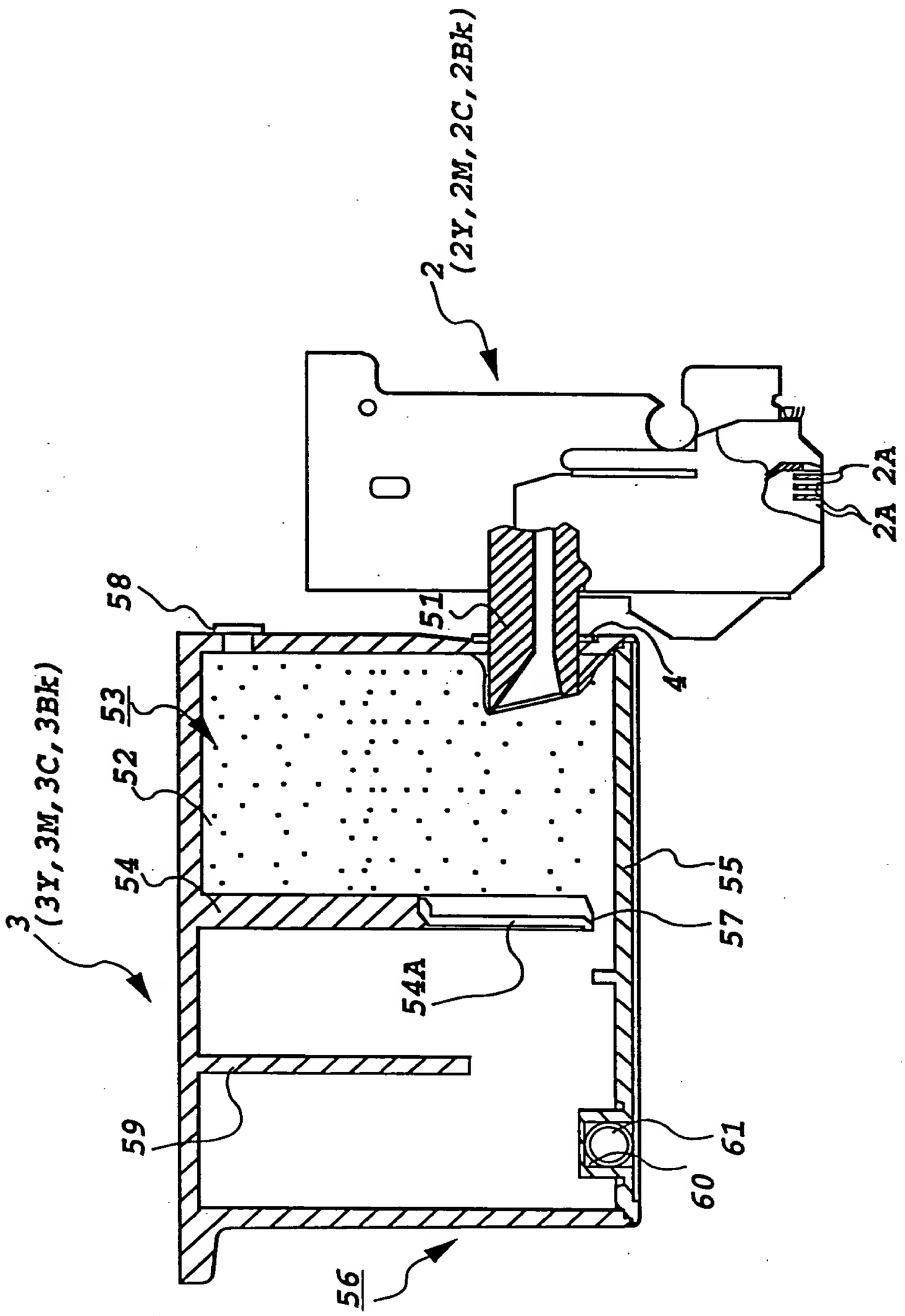
2
(2Y, 2M, 2C, 2Bk)
2A
2A
58
51
4
53
52
54
3
(3Y, 3M, 3C, 3Bk)
57
55
54A
59
61
60
56

FIG.3

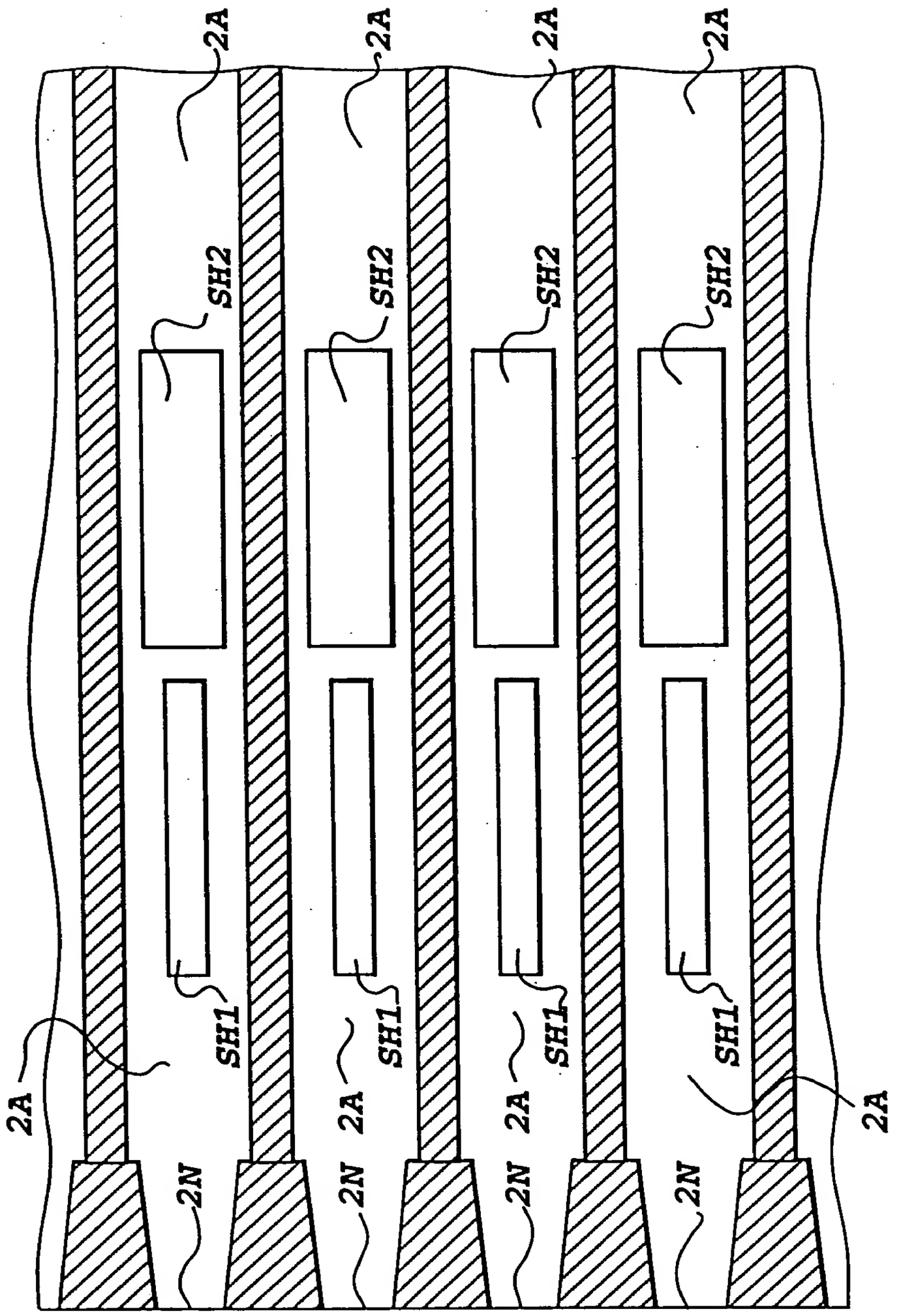

FIG.4

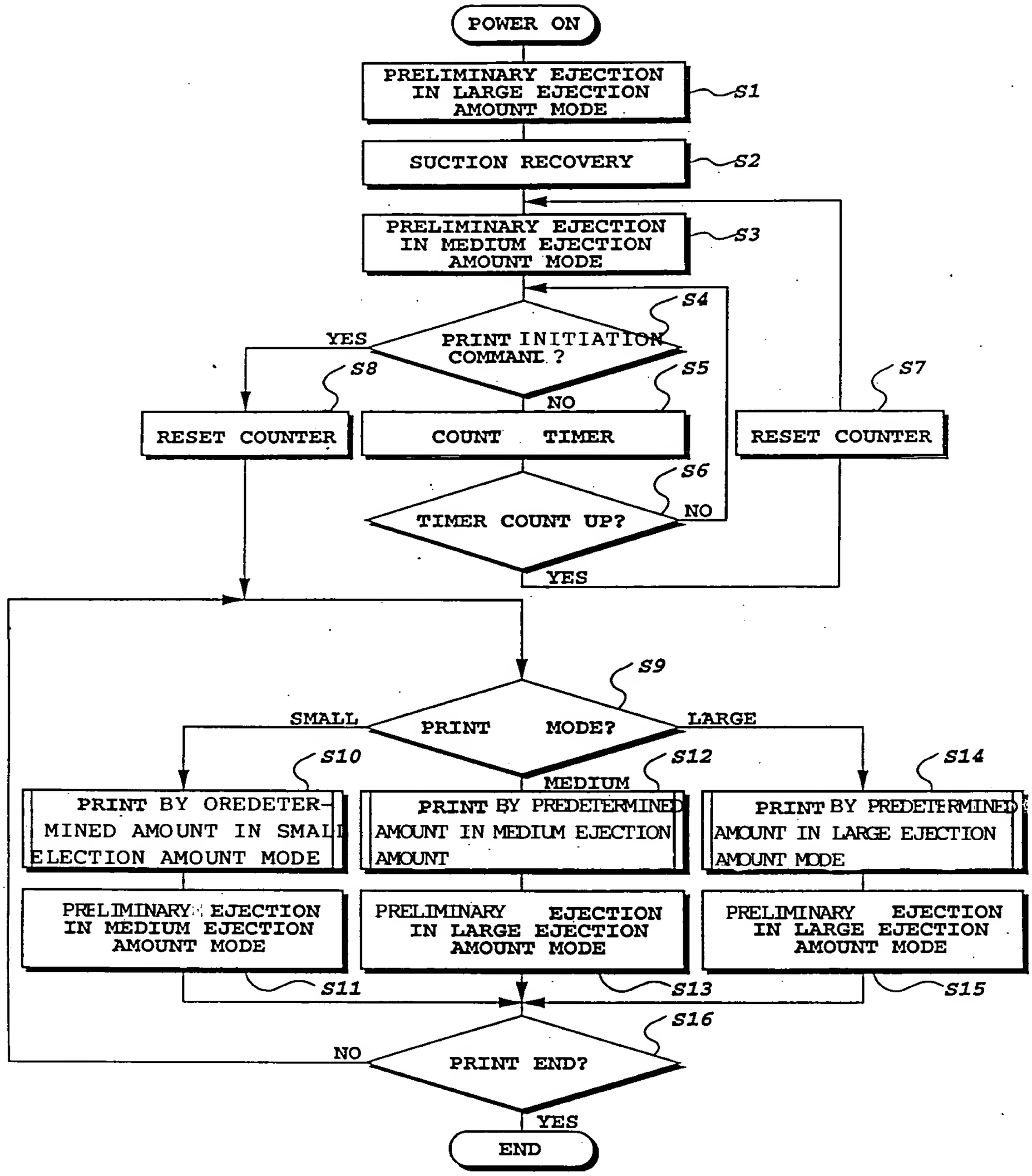
POWER ON
PRELIMINARY EJECTION IN LARGE EJECTION AMOUNT MODE
S1
SUCTION RECOVERY
S2
PRELIMINARY EJECTION IN MEDIUM EJECTION AMOUNT MODE
S3
S4
PRINT INITIATION COMMAND ?
YES
NO
S8
S5
S7
RESET COUNTER
COUNT TIMER
RESET COUNTER
S6
TIMER COUNT UP?
NO
YES
S9
SMALL
PRINT MODE?
LARGE
MEDIUM
S10
S12
S14
PRINT BY OREDETERMINED AMOUNT IN SMALL EJECTION AMOUNT MODE
PRINT BY PREDETERMINED AMOUNT IN MEDIUM EJECTION AMOUNT
PRINT BY PREDETERMINED AMOUNT IN LARGE EJECTION AMOUNT MODE
PRELIMINARY EJECTION IN MEDIUM EJECTION AMOUNT MODE
PRELIMINARY EJECTION IN LARGE EJECTION AMOUNT MODE
PRELIMINARY EJECTION IN LARGE EJECTION AMOUNT MODE
S11
S13
S15
S16
NO
PRINT END?
YES
END

FIG5

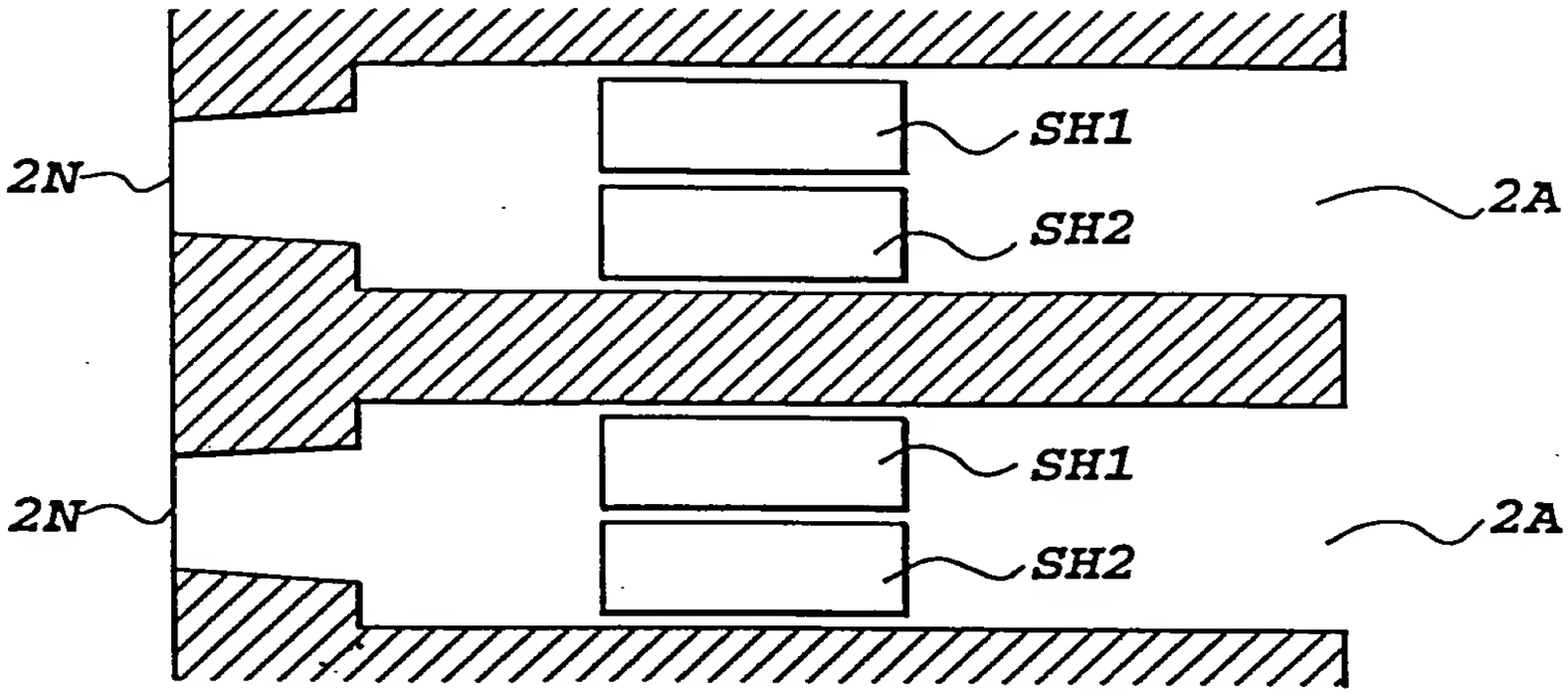

FIG.6(a)

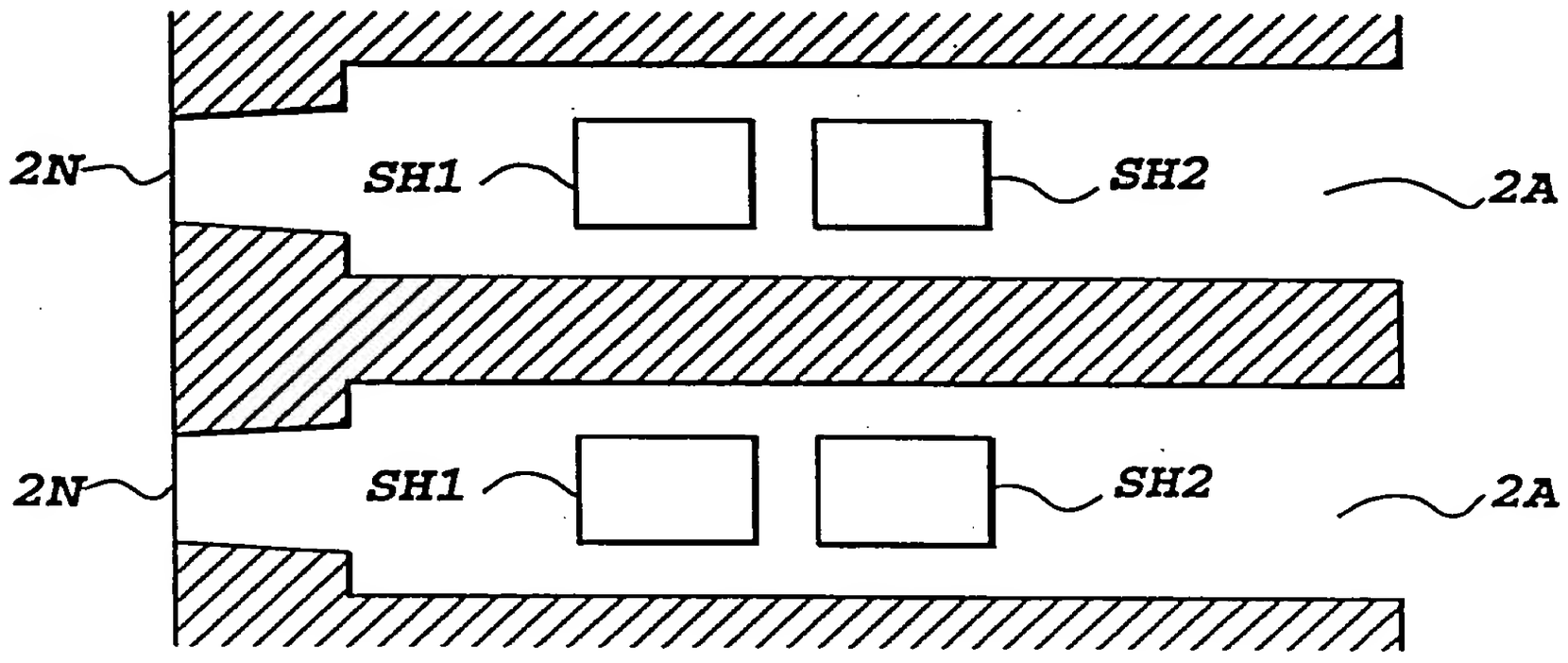

FIG.6(b)

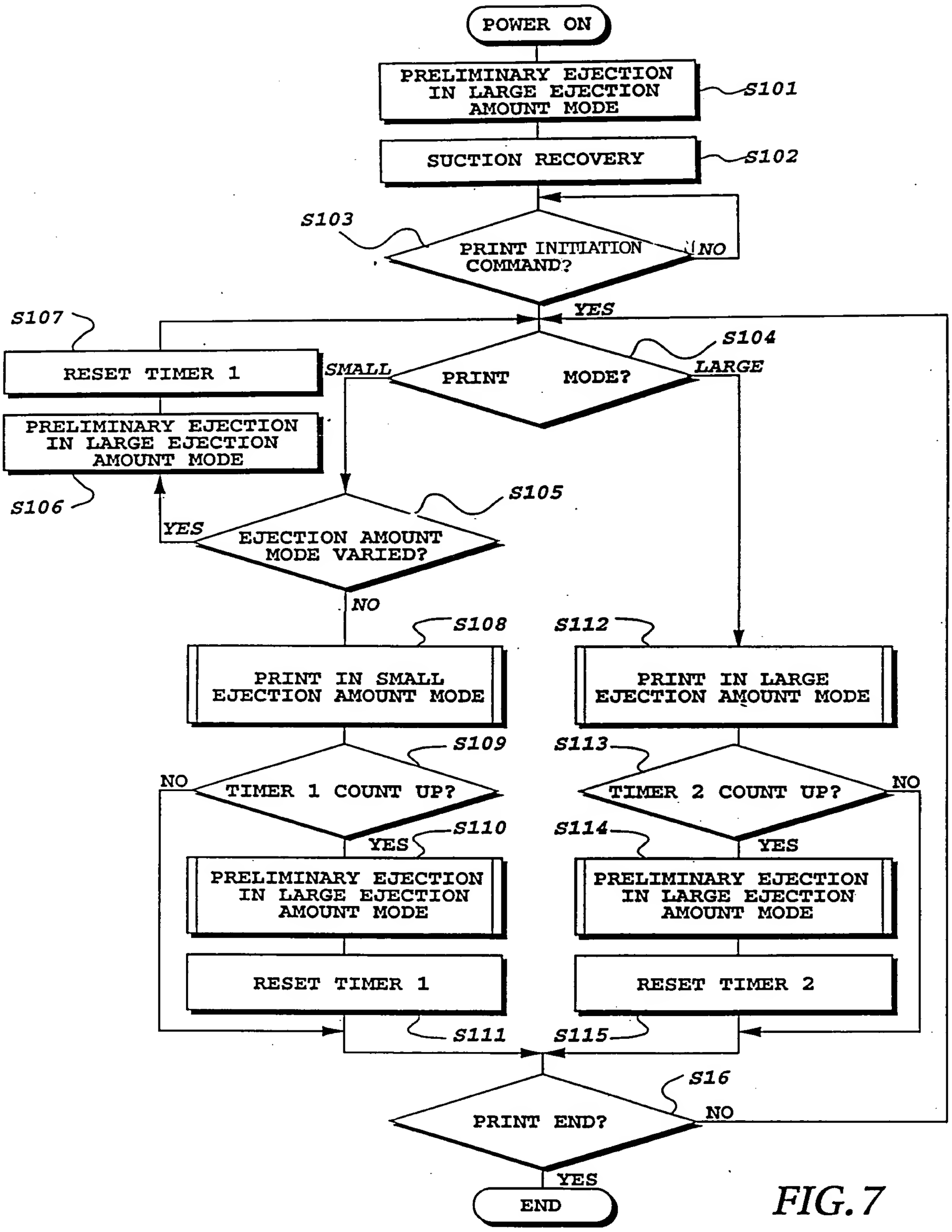
POWER ON
PRELIMINARY EJECTION IN LARGE EJECTION AMOUNT MODE
S101
SUCTION RECOVERY
S102
S103
PRINT INITIATION COMMAND?
NO
YES
S104
PRINT MODE?
SMALL
LARGE
S105
EJECTION AMOUNT MODE VARIED?
YES
NO
S106
PRELIMINARY EJECTION IN LARGE EJECTION AMOUNT MODE
S107
RESET TIMER 1
S108
PRINT IN SMALL EJECTION AMOUNT MODE
S109
TIMER 1 COUNT UP?
NO
YES
S110
PRELIMINARY EJECTION IN LARGE EJECTION AMOUNT MODE
RESET TIMER 1
S111
S112
PRINT IN LARGE EJECTION AMOUNT MODE
S113
TIMER 2 COUNT UP?
NO
YES
S114
PRELIMINARY EJECTION IN LARGE EJECTION AMOUNT MODE
RESET TIMER 2
S115
S16
PRINT END?
NO
YES
END

FIG. 7

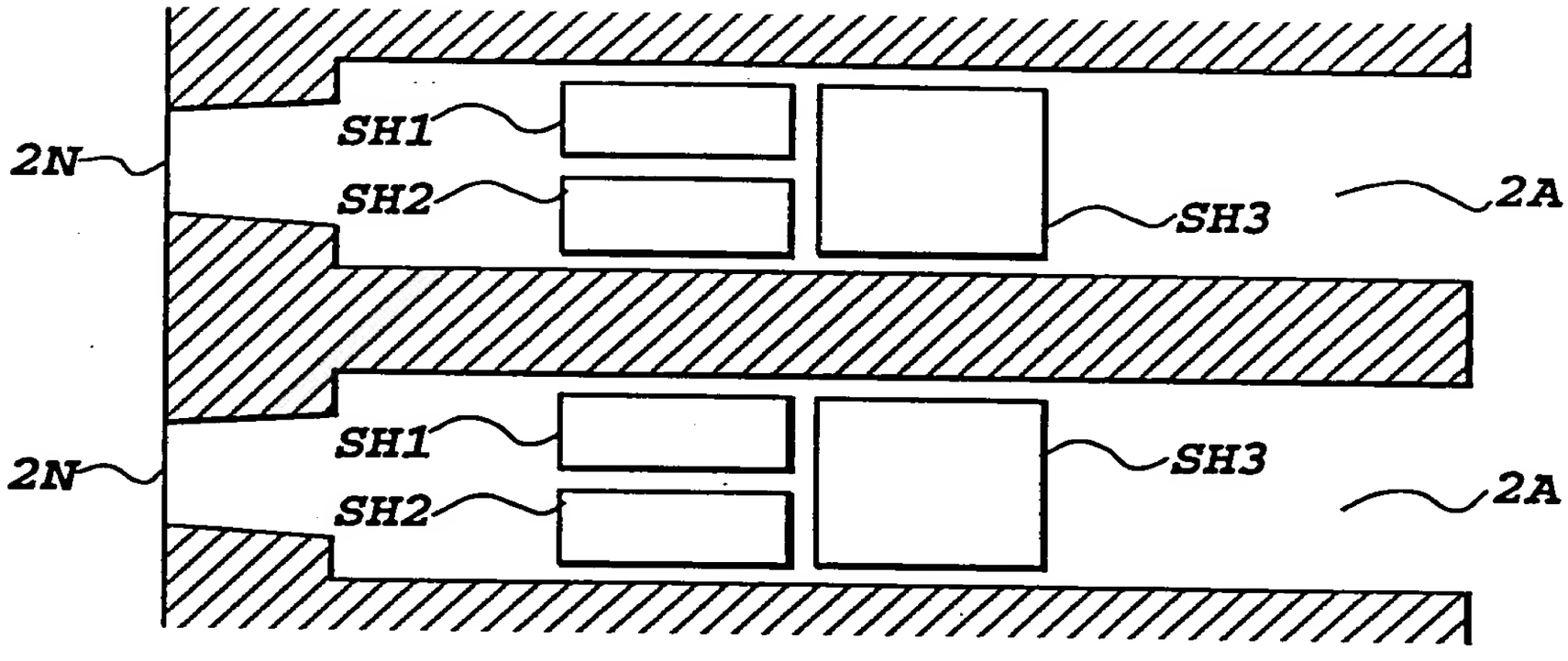

FIG.8 (a)

[Document Name] Correction Data Ex Offico

[Document Corrected] Patent Application

<Information Acknowledged · Information Added>

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1. Date of Change August 30, 1990

[Reason for Change]New Registration

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[DOCUMENT NAME] ABSTRACT

[Abstract]

[Object]

In an ink-jet apparatus using an ink-jet head having a plurality of heaters corresponding to one ink ejection opening, appropriate preliminary ejection is performed per ejection amount mode set by a heater to be used out of the plurality of heaters, so as to prevent any decrease in throughput.

[Construction]

According to a printing mode set (step S9), printing is performed in any one of large, medium and small ejection amount modes (step S10, S12 or S14). For example, after the printing is performed by a predetermined amount in the small ejection amount mode (step S10), preliminary ejection during the printing is performed in the medium ejection amount mode which is greater in ejection amount than that in the small ejection amount mode. Consequently, the interval of the preliminary ejection during the printing can be lengthened so as to prevent any decrease in throughput caused by the preliminary ejection.

[Figure Selected]

Fig. 5

12.12.19 B

整理番号　２８８２０１６　　発送番号　３６３８７４
発送日　平成１２年１２月１５日　　1／ 3

拒絶理由通知書

特許出願の番号	平成　６年　特許願　第３４０２６６号
起案日	平成１２年１２月１１日
特許庁審査官	桐畑　幸▲廣▼　　９６０６　２Ｐ００
特許出願人代理人	谷　義一　　（外　１名）様
適用条文	第２９条第２項、第２９条の２、第３６条

この出願は、次の理由によって拒絶をすべきものである。これについて意見があれば、この通知書の発送の日から６０日以内に意見書を提出して下さい。

理　由

［理由１］
本願の下記の請求項に係る発明は、下記引用例に記載された発明に基づいて、当業者が容易に発明をすることができたものであるから、特許法第２９条第２項の規定により特許を受けることができない。

記

・請求項　２～４，６～１０，１２～１５
・引用例　1．特公昭６２－４６３５８号公報
　　2．特開平５－３１９０５号公報
　　3．特開平３－２８４９５１号公報
・備考
上記引用例１には、１のインク吐出口に対応して設けられた複数のヒータを選択的に加熱することにより、インク吐出量を変えることができるインクジェット記録装置が記載されている。
また、上記引用例２又は３には、電気熱変換体にサブパルスとメインパルスを

続葉有

続　葉

印加して階調印字を行うインクジェット記録装置であって、記録ヘッドの温度に応じて前記パルスを変化させる技術が記載されており、引用例１に記載された発明に、引用例２又は３に記載された上記技術を適用することは、当業者が容易に想到し得ることであり、その効果も当業者が予測し得る程度のものである。

［理由２］

本願の下記の請求項に係る発明は、下記先願の願書に最初に添付された明細書又は図面に記載された発明と同一であり、しかも、本願の発明者が先願の発明者と同一ではなく、また本願の出願の時において、本願の出願人が先願の出願人と同一でもないので、特許法第２９条の２の規定により、特許を受けることができない。

記

・請求項　２，４，６，９，１０，１２～１５
・引用例　４．特願平６－２４５７２号(特開平７－２３２４４１号)
・備考

上記引用例４には、１つのインク噴出口１３に対して、第一の電熱変換素子１８と第二の電熱変換素子１０とが設けられ、該電熱変換素子１８，１９の各々に印加されるプリパルスとメインパルスとの間のインターバルタイムを制御することにより階調印字を行うインクジェット記録装置が記載されている（【請求項１】～【請求項４】及び【図５】参照)。

［理由３］

この出願は、特許請求の範囲の記載が下記の点で、特許法第３６条第５項第２号及び第６項に規定する要件を満たしていない。

記

１．請求項１における「・・インク温度に関する情報に基づき前記ヘッド駆動手段を介した前記先行パルスの印加を制御する」ことの技術的内容が不明瞭であるから、特許を受けようとする発明の構成に欠くことができない事項が不明瞭である。
２．請求項４，５の「および／または」という記載は、日本語として不明瞭であるから、特許を受けようとする発明の構成に欠くことができない事項が不明瞭

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である。

この拒絶理由通知の内容に関するお問い合わせ、または面接のご希望がございましたら下記までご連絡下さい。

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先行技術文献調査結果の記録

・調査した分野　　ＩＰＣ第７版　Ｂ４１Ｊ　２／０５
　　Ｂ４１Ｊ　２／２０５

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B

(Translation)

Case No.: 2882016 Mailing Number: 363874
Mailing Date: December 15, 2000

OFFICIAL NOTICE OF REJECTION

Patent Application No. 340,266/1994

Date of Draft: December 11, 2000

Examiner, The Patent Office: Y. Kirihata 9606 2P00

Agent for Applicant: Yoshikazu Tani, Esq. (and one other)

Applied Provision(s): Section 29, Paragraph 2, Section 29bis, And Section 36, Paragraph 5, Item 2

The present application is rejected for the following reasons. The applicant may present an argument, if any, within 60 days from the mailing date of this Official Notice.

Reason 1

The invention(s) of the present application as claimed in claim(s) set forth below would have been obvious to one skilled in the art, to which the invention(s) pertain(s), prior to the filing date of the present application, on the basis of the publication(s) set forth below as distributed in Japan or foreign countries prior to the filing date of the present application. Thus, the present invention(s) is(are) unpatentable under the provision of Section 29, Paragraph 2 of the Patent Law.

Note

- Claims 2 to 4, 6 to 10, and 12 to 15
- References

1. Japanese Patent Application Publication No. Sho 62-46358

2. Japanese Patent Application Laid-open No. Hei 5-31905
3. Japanese Patent Application Laid-open No. Hei 3-284951

- Remark

Reference 1 discloses an ink jet printing apparatus for selectively heating a plurality of heaters provided so as to correspond to one ink ejection port, thereby making it possible to change an ink ejection quantity.

Further, Reference 2 or 3 relates to an ink jet printing apparatus for applying a sub-pulse and a main pulse to an electric heat converter to perform gradation printing and discloses a technique of changing the pulses according to a temperature of printing heads. It would have been obvious for one skilled in the art to apply the above technique of Reference 2 or 3 to the invention of Reference 1. Further, the advantageous result is of mere level that could have been expected by one skilled in the art.

Reason 2

The invention(s) of the present application as claimed in claim(s) set forth below could have been obvious to one skilled in the art, to which the invention(s) pertain(s), on the basis of the publication(s) set forth below as distributed in Japan or foreign countries prior to the filing date of the present application. Therefore, the present invention(s) is(are) unpatentable under the provision of Section 29^{bis} of the Japanese Patent Law.

Note

- Claims 2, 4, 6, 9, 10, and 12 to 15
- References 4

Japanese Patent Application No. Hei 6-24572 (Laid-open No. Hei 7-232441)

- Remark

Reference 4 discloses an ink jet printing apparatus, wherein a first electric heat converting element 18 and a second electric heat converting element 10 are provided for one ink jetting portion 13, and a time interval between a pre-pulse and a main pulse that are applied to each of the electric heat converting elements 18 and 19, thereby performing gradation printing (refer to Claims 1 to 4 and Fig. 5).

Reason 3

The descriptions of the specification and the accompanying drawings of the present application fail to conform to the requirements prescribed under the provision of Section 36, Paragraph 5, Item 2 and Paragraph 6 of the Japanese Patent Law in the point(s) as mentioned below.

Note

1. Claim 1 recites "... controlling application of said preceding pulse via said head driving means based on information concerning an ink temperature". However, this recitation is unclear in its technical contents, thus obscuring a matter indispensable for the constitution of the invention for which a patent is sought.

2. A word "and/or" recited in claims 4 and 5 is unclear in the Japanese language, thus obscuring a matter indispensable for the constitution of the invention for which a patent is sought.

Record of Search Result of Prior Art Literature

- Searched Field

IPC seventh edition B41J 2/05
B41J 2/205

This record of search result of prior art literature does not constitute reason for rejection.

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Group Art unit: 2853

Examiner: S. Johnson, Jr.

Applicants	:	**Noribumi KOITABASHI et al.**	)
Application No.:		**08/579,241**	) TRANSLATION OF PRIORITY DOCUMENTS DECLARATION IN SUPPORT THEREOF
Filed	:	**December 28, 1995**	)
For	:	**INK-JET APPARATUS EMPLOYING INK-JET HEAD HAVING A PLURALITY OF INK EJECTION HEATERS CORRESPONDING TO EACH INK EJECTION OPENING**	)

Assistant Commissioner for Patents
Washington, D.C. 20231

Sir:

I, Atsuko SEKIGUCHI, of Tani & Abe Patent Office, No. 6-20, Akasaka 2-chome, Minato-ku, Tokyo 107-0052, Japan, declare that:

1. I know well both the Japanese and English languages.

2. I translated Japanese Patent Application No. 340266/1994 of December 29, 1994 from the Japanese language to the English language, a copy of the translation being attached hereto.

3. The attached English translation of the Japanese application identified in paragraph 2 above is a true and correct translation to the best of my knowledge and belief.

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code, and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

Signed this July 17, 2000

Atsuko Sekiguchi

Atsuko SEKIGUCHI

PATENT OFFICE
JAPANESE GOVERNMENT

This is to certify that the annexed is a true copy of the following application as filed with this Office.

Date of Application: December 29, 1994

Application Number: Japanese Patent Application No. 340266/1994

Applicant(s): CANON KABUSHIKI KAISHA

January 26, 1996

Commissioner,
Patent Office Yuji KIYOKAWA

Certificate No. 3085353/1995

Applicant's Case Number: 2882016

(Document's Name) Patent Application

(Case Number) 2882016

(Filing Date) December 29, 1994

To: Commissioner, the Patent Office

(International Patent Classification) B41J 2/01

(Title of the Invention)

AN INK-JET APPARATUS

(Number of claims) 15

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340266/1994

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Specification	1 copy
Formal Drawings	1 copy
Abstract	1 copy
General Authorization Number	9004548

(Necessity of Proof) Yes

[DOCUMENT NAME] SPECIFICATION

[TITLE OF THE INVENTION]

An Ink-Jet Apparatus

[SCOPE OF CLAIM FOR A PATENT]

[Claim 1]

An ink-jet apparatus in which an ink-jet head having a plurality of heaters for one ink ejection opening is used to eject ink therefrom to a medium, the ink-jet apparatus comprising:

head driving means capable of applying a preceding pulse which does not cause ejection and a following pulse following the preceding pulse which causes bubbles so as to eject the ink;

ejection amount mode setting means for setting an ejection amount mode by selecting a heater, to which the following pulse is to be applied, out of the plurality of heaters; and

pre-pulse control means for controlling the application of the preceding pulse via the head driving means in each of the ejection amount modes set by the ejection amount mode setting means on the basis of information relating to an ink temperature of the ink-jet head.

[Claim 2]

An ink-jet apparatus in which an ink-jet head having first and second heaters disposed for one ink ejection opening is used to cause bubbles by

driving the first and second heaters in combination so as to eject ink droplets in a plurality of ejection amounts, the ink-jet apparatus comprising:

driving means for applying a pre-heating pulse prior to a main heating pulse for causing the ejection of the ink droplets.

[Claim 3]

An ink-jet apparatus as claimed in claim 2, wherein the ink-jet head has an ejection amount mode established by the first heater, another ejection amount mode established by the second heater, and a further ejection amount mode established by the first and second heaters.

[Claim 4]

An ink-jet apparatus as claimed in claim 2 or claim 3, wherein the pre-heating pulse is controlled on the basis of at least temperature information of the ink-jet head and/or a calculation value of a temperature of the ink-jet head.

[Claim 5]

An ink-jet apparatus as claimed in claim 3, wherein the heater to be driven by the pre-heating pulse is set and/or a pre-heating control mode is varied according to the ejection amount mode.

[Claim 6]

An ink-jet apparatus as claimed in any one of claims 2 to 5, wherein the heater for main heating performs at least pre-heating.

[Claim 7]

An ink-jet apparatus as claimed in any one of claims 2 to 5, wherein the heater other than the heater for main heating is pre-heated.

[Claim 8]

An ink-jet apparatus as claimed in claim 4, wherein the pre-heating is controlled by varying a pulse width of the pre-heating pulse.

[Claim 9]

An ink-jet apparatus as claimed in claim 4, wherein the pre-heating is controlled by varying a time interval between the pre-heating pulse and the main heating pulse.

[Claim 10]

An ink-jet apparatus as claimed in any one of claims 3 to 9, wherein a control mode is varied according to the ejection amount mode.

[Claim 11]

An ink-jet apparatus as claimed in any one of claims 4 to 10, wherein the heater to be driven by the pre-heating pulse is switched according to a head temperature.

[Claim 12]

An ink-jet apparatus as claimed in any one of claims 4 to 11, wherein the different heaters apply the pre-heating pulse and the main heating pulse, respectively.

[Claim 13]

An ink-jet apparatus in which an ink-jet head having a plurality of different heaters disposed for one ink ejection opening is used to cause bubbles by driving the plurality of heaters in combination so as to eject ink droplets in a plurality of ejection amounts, the ink-jet apparatus comprising:

tables for driving the heaters according to each of the combinations of the plurality of heaters.

[Claim 14]

An ink-jet apparatus as claimed in claim 13, wherein the tables include a table for simultaneously driving two or more of the plurality of heaters.

[Claim 15]

An ink-jet apparatus as claimed in claim 13 or claim 14, wherein the tables are switched according to the temperature information of the ink-jet head.

[DETAILED DESCRIPTION OF THE INVENTION]

[0001]

[Field of Industrial Utilization]

The present invention relates to an ink-jet apparatus. More specifically, the invention relates to an ink-jet apparatus using an ink-jet head having a plurality of ejecting heaters on an ink path corresponding to each of ink ejection openings.

[0002]

[Prior Art]

An ink-jet apparatus has been mainly known as a printing apparatus in printers, copy machines and the like. Among various ink-jet apparatus, there has become recently widespread an ink-jet printing apparatus of the type in which thermal energy is used as energy for ink ejection, for ejecting ink with bubbles generated by the thermal energy. In addition, as other applications of this type of ink-jet printing apparatus has become known in recent years an ink-jet textile printing apparatus for printing a given pattern, a picture, a synthesized image or the like on cloth.

[0003]

An ink-jet head for use in such an ink-jet printing apparatus as described above has an electrothermal transducer element (hereinafter

also referred to as "a heater") as a source for generating thermal energy. In most cases, the ink-jet head is provided with one heater corresponding to one ejection opening. In contrast, there has been known an ink-jet head using a plurality of heaters in each of ink ejection openings for the reasons discussed below.

[0004]

First, it has been known to alternately or selectively drive a plurality of heaters for the purpose of extension of the life of the ink-jet head. Second, a plurality of heaters are used for widening the range of variations in ink ejection amount, wherein the ink ejection amount is varied by selecting heaters to be driven or the number of heaters to be driven.

[0005]

In the latter case, in a more specific structure, a plurality of heaters are arranged along an ink ejecting direction on an ink path communicating with the ejection opening in the ink-jet head, so that a distance between the ejection opening and the heaters to be driven is varied by selecting the heaters to be driven (namely, the heaters to be made to generate heat) or the number of heaters to be driven, thus varying the ejection amount of the ink.

[0006]

Another structure of the ink-jet head has been known in which a plurality of heaters different in surface area are arranged on an ink path, to make an ink ejection amount variable by varying the heaters to be driven or the number of heaters to be driven.

[0007]

In ink-jet heads of the type in which the ink is ejected using the above-described heater, when a head temperature or, more particularly, an ink temperature is varied, the ink ejection amount can be varied even if the variation range is not so significant. Therefore, when the head temperature is elevated according to the progress of printing operation, a problem of variations in image quality can be caused due to variations in ejection amount. In order to solve the above-described problem, the applicant of the present invention has already proposed the structure for stabilizing the ejection amount regardless of the variations in head temperature, as disclosed in Japanese Patent Application Laid-open No. 31905/1993. Here, two sequential pulses are applied to the heater in each ink ejection for controlling a pulse width or the like of a preceding one out of the two pulses (hereinafter

also referred to as "pre-heating control"), thereby controlling the head temperature so as to stabilize the ejection amount.

[0008]

[Problems to be Solved by the Invention]

In the structure in which the ejection amount can be varied in multiple modes by selecting the heaters to be driven in the above-described ink-jet head by using the plurality of ejecting heaters, it is, of course, desirable to stably maintain each of set ejection amounts.

[0009]

In this case, it is considered to use the constitution of the pre-heating control. However, there are not a few problems to be taken into consideration when the ejection amount is optimally controlled at each of the set ejection amounts such as the relationship between the driven heater in the set ejection amount and the heater performing pre-heating at that time or the relationship between the set ejecting amount and the width of the pre-heating pulse.

[0010]

The present invention has been accomplished in view of the above-described problems. An object of the present invention is to provide an ink-jet apparatus which can stably control an

ejection amount with respect to each of a plurality of set ejection amounts.

[0011]

[Means for Solving the Problems]

According to the present invention, an ink-jet apparatus in which an ink-jet head having a plurality of heaters for one ink ejection opening is used to eject ink therefrom to a medium, comprises: head driving means capable of applying a preceding pulse which does not cause ejection and a following pulse following the preceding pulse which causes bubbles so as to eject the ink; ejection amount mode setting means for setting an ejection amount mode by selecting a heater, to which the following pulse is to be applied, out of the plurality of heaters; and pre-pulse control means for controlling the application of the preceding pulse via the head driving means in each of the ejection amount modes set by the ejection amount mode setting means on the basis of information relating to an ink temperature of the ink-jet head.

[0012]

Furthermore, an ink-jet apparatus in which an ink-jet head having first and second heaters disposed for one ink ejection opening is used to cause bubbles by driving the first and second

heaters in combination so as to eject ink droplets in a plurality of ejection amounts, comprises driving means for applying a pre-heating pulse prior to a main heating pulse for causing the ejection of the ink droplets.

[0013]

Moreover, an ink-jet apparatus in which an ink-jet head having a plurality of different heaters disposed for one ink ejection opening is used to cause bubbles by driving the plurality of heaters in combination so as to eject ink droplets in a plurality of ejection amounts, comprises tables for driving the heaters according to each of the combinations of the plurality of heaters.

[0014]

[Function]

With the above-described configuration, the heaters can be controlled to be driven in each of the combinations of the heaters set to be driven out of the plurality of heaters, and thus, the pre-pulses to be applied for stabilizing the ejection amount can be controlled in each of the combinations.

[0015]

[Preferred Embodiments]

Preferred embodiments according to the present invention will be discussed hereinafter in detail with reference to the accompanying drawings.

[0016]

Fig. 1 is a perspective view showing a printer as an ink-jet printing apparatus according to the present invention.

[0017]

In Fig. 1, reference numeral 101 denotes a printer, reference numeral 102 denotes an operation panel provided at the upper front portion of a housing of the printer 101, reference numeral 103 denotes a sheet feeding cassette to be inserted into an opening at the front face of the housing, reference numeral 104 denotes a sheet (recording medium) to be fed from the sheet feeding cassette 103, and reference numeral 105 denotes a discharged sheet tray for holding sheets discharged via a sheet feeding path inside the printer 101. Reference numeral 106 denotes a main body cover in an L-shaped cross section. The main body cover 106 is designed for covering an opening 107 formed at the right front portion of the housing, and is pivotally mounted at the inner end of the opening 107 by means of a hinge 108. In

addition, within the housing, a carriage 110 supported by a guide or the like (not shown) is arranged. The carriage 110 is provided in such a manner as to movably reciprocate in a width direction of the sheet to be fed on the sheet feeding path (hereinafter also referred to as "a primary scanning direction").

[0018]

The carriage 110 in the present embodiment generally comprises a stage 110a to be held horizontally by the guide or the like, an opening (not shown) for accommodating ink-jet heads at a rear portion on the stage 110a, a cartridge garage 110b for receiving ink-jet heads 3Y, 3M, 3C and 3Bk which are detachably loaded on the stage 110a in front of the opening, and a cartridge holder 110c opened and closed relative to the garage 110b so as to prevent any detachment of a cartridge received within the garage 110b.

[0019]

The stage 110a is slidably supported at the rear end thereof by means of a guide, and further, slidably engages with a not-shown guide plate at the lower portion of the front end thereof. The guide plate may serve as a sheet holding member for preventing the sheet fed via the sheet feeding path from floating, or may have a function of

lifting up the stage relative to the guide in a cantilever fashion according to the thickness of the sheet.

[0020]

In the opening of the stage 110a is loaded the ink-jet head (not shown) with ink ejecting openings directed downward.

[0021]

The cartridge garage 110b is provided with a through opening extending in a lengthwise direction, for simultaneously receiving the four ink-cartridges 3Y, 3M, 3C and 3Bk. On the both sides of the outer surfaces of the cartridge garage 110b are formed engaged recesses to be engaged with engaging claws of the cartridge holder 110c.

[0022]

At the front end of the stage 110a, the cartridge holder 10c is pivotally mounted via a hinge 116. The dimension from the front end of the garage 110b to the hinge 116 is determined in consideration of a projecting dimension from the cartridges 3Y, 3M, 3C and 3Bk from the front end of the garage 110b when the cartridges 3Y, 3M, 3C and 3Bk are received inside the garage 110b. The cartridge holder 110c is formed into a substantially rectangular plate. On the cartridge

holder 110c, a pair of engaging claws 110e project in a direction perpendicular to the plate surface on both sides of the upper portion away from the lower portion fixed via the hinge 116, and engage with engaged recesses 110d formed at the garage 110b when the holder 110c is closed. An insertion hole 120, to which the respective handles of the cartridges 3Y, 3M, 3C and 3Bk are inserted, is formed in the plate of the holder 110c. The insertion hole 120 is formed into a corresponding shape at a corresponding position in a corresponding size to the handles.

[0023]

Fig. 2 is a block diagram illustrating an example of the arrangement of a control system in the ink-jet printing apparatus.

[0024]

Here, reference numeral 200 denotes a controller constituting a main control unit, which includes a CPU 201 in a form of, for example, a microcomputer for executing various modes, described later, a ROM 203 storing therein fixed data such as programs, tables, voltage values of a heat pulse and pulse widths, and a RAM 205 provided with a region for developing image data and a region for working. Reference numeral 210 denotes a host system (or a reader unit for

reading an image) serving as a supply source of the image data. The image data, other commands, status signals and the like are transmitted to or received from the controller via an interface (I/F) 212.

[0025]

The operation panel 102 is provided with a switch group which receives commands input by an operator and includes a mode selector switch 220 for selecting various modes, a power source switch 222, a print switch 224 for designating starting of printing, an ejection recovering switch 226 for designating initiation of ejection recovering processes, and the like, as described later. Reference numeral 230 denotes a sensor group which detects the condition of the apparatus and includes a sensor 232 for detecting positions of the carriage 110 (see Fig. 1) such as a home position and a start position, and a sensor 234 to be used for detecting a pump position including a leaf switch.

[0026]

Reference numeral 240 denotes a head driver for driving an electrothermal transducer element of the ink-jet head in accordance with printing data and the like. A part of the head driver also may be used for driving temperature heaters 30A

and 30B. Furthermore, temperature detection values are input to the controller 200 from temperature sensors 20A and 20B. Reference numeral 250 denotes a primary scanning motor for shifting the carriage 110 in a primary scanning direction, and reference numeral 252 denotes a driver for the motor 250. Reference numeral 260 denotes an auxiliary scanning motor which is used for feeding the sheet 104 as the recording medium (see Fig. 1).

[0027]

The above-mentioned ink-jet printing apparatus has the ink-jet head cartridges 2C, 2M, 2Y and 2Bk for inks of four colors, i.e., cyan, magenta, yellow and black, respectively.

[0028]

Fig. 3 is a cross-sectional view showing an ink tank cartridge 3 and an ink-jet head 2 to be used in the above-mentioned ink-jet printing apparatus in a connected state.

[0029]

The ink tank cartridge 3 used in the present embodiment includes two chambers of a vacuum generating member containing chamber 53 filled with ink absorbers 52, and an empty ink containing chamber 56. In the initial condition, ink is filled in both of these chambers. In association

with ink ejection and the like in the ink-jet head 2, the ink in the ink containing chamber 56 is first consumed.

[0030]

The ink-jet head 2 has heaters (not shown in Fig. 3) for generating thermal energy to be used for ejection on a plurality of ink paths 2A corresponding to the ink ejection openings, for ejecting the ink supplied from the ink tank cartridge 3 via a connection pipe 4.

[0031]

Fig. 4 is a cross-sectional view schematically showing the structure of the ink-jet head 2 in the first embodiment according to the present invention.

[0032]

As shown in Fig. 4, two heaters SH1 and SH2 are arranged on each of the ink paths 2A in the longitudinal direction. The two heaters are different in surface area from each other, and electrodes are wired (not shown) such that the heaters can be driven independently of each other or simultaneously. It should be noted that the heaters SH1 and SH2 are the same in length in the longitudinal direction of the ink path 2A but are different in width, and therefore, they are different in surface area from each other. At the

tip end of the ink path 2A is opened an ejection opening 2N.

[0033]

The structures, which are provided in the predetermined number per ink path and each of which consists of the heaters, the ejection opening and the ink path, are arranged in the ink-jet head 2 in the density of 360 DPI. In the present embodiment, the area of the ejection opening and the area of the heater are the same in each ink path.

[0034]

In the present embodiment, basically, the ink ejection amount can be set at three steps (hereinafter referred to as "basic ejection amount modes") according to the combination of the heaters to be driven in each of the ejection openings in the case where two heaters are used.

[0035]

Basic ejection amount modes in the present embodiment can be fundamentally set in three ejection amount modes, i.e., small, medium and large ejection amount modes by switching the heater to be driven. In the small ejection amount mode, only the heater SH1 is driven to eject 15 pl in volume of liquid droplets; in the medium ejection amount mode, only the heater SH2 is

driven to eject 25 pl in volume of ink droplets; and in the large ejection amount mode, both of the heaters SH1 and SH2 are simultaneously driven to eject 40 pl (= 15 + 25 pl) of liquid droplets.

[0036]

Next, explanation will be made below on ejection stabilizing control in the present embodiment.

[0037]

Fig. 5 is a graph illustrating the temperature dependency of the ejection amount in the above-described ejection amount modes in the configuration of an ink jet-head in the present embodiment. Under the driving condition illustrated in Fig. 5, a rectangular pulse having a voltage of 18 V and a pulse width of 5 μsec is applied to each of the heaters SH1 and SH2.

[0038]

As illustrated in Fig. 5, the ejection amount is increased with an increased head temperature. Within a range illustrated in Fig. 5, the ejection amount is substantially linearly varied. The variation ratio of the ejection amount Vd to the temperature T is designated by α in the small ejection amount mode, β in the medium ejection amount mode and γ in the large ejection amount mode.

[0039]

In contrast, a drive pulse consisting of two pulses (hereinafter also referred to as "a double pulse") illustrated in Fig. 6 is applied at a constant environmental temperature. Fig. 7 illustrates the ejection amount when a width P1 of a pre-pulse is varied.

[0040]

P1 designates the width of the pre-heating pulse in the double pulse illustrated in Fig. 6. Ink in the vicinity of the heater is heated by the pre-heating pulse to such an extent that no bubble can be generated. Subsequently, after a lapse of a quiescent period P2, a main heating pulse having a pulse width P3 is applied to generate bubbles so as to eject the ink.

[0041]

In the case of such double pulse driving, when the pre-heating pulse P1 is increased, as illustrated in Fig. 7, the ejection amount is increased at a constant rate in any ejection amount mode.

[0042]

Consequently, by utilizing the relationship illustrated in Fig. 7 and the relationship illustrated in Fig. 5, the ejection amount can be controlled at a predetermined value irrespective

of variations in head temperature, as illustrated in Fig. 8, by varying the pre-pulse width P1 according to the head temperature. Namely, as the head temperature becomes higher, the pre-pulse width P1 is controlled to be smaller accordingly.

[0043]

Fig. 9 is a block diagram illustrating one example of the basic construction of the ejection amount control.

[0044]

In Fig. 9, with reference to a drive waveform parameter setting table 210 on the basis of the head temperature from a head temperature detector 212 including temperature sensors 20A and 20B (see Fig. 2), the parameters of the pulse waveform such as the pre-pulse, the quiescent period and the main pulse width are output to driving waveform setters 211A and 211B.

[0045]

In the driving waveform setters 211A and 211B, any one of three waveforms designated by 1 to 3 corresponding to the heaters SH1 and SH2 is selected according to the input ejection amount mode. At the same time, the parameters such as the pulse width input from the table 210 are set. In the waveform selection from the waveforms 1 to 3 for the heaters SH1 and SH2 according to the

ejection amount mode, the main pulses are applied to both of the heaters SH1 and SH2, for example, in the large ejection amount mode, and therefore, the waveform 2 or 3 is to be selected. However, the waveform 3 including at least the pre-pulse must be selected corresponding to either of the heaters.

[0046]

However, since the dependency of the ejection amount is different in each ejection amount mode, as described in reference to Fig. 7, it is more desirable to provide the parameter setting table for each ejection mode.

[0047]

Fig. 10 is a block diagram illustrating the configuration in which the parameter can be set in each ejection amount mode. Fig. 11 conceptually illustrates a table for setting the driven heater according to the ejection amount mode in the configuration illustrated in Fig. 10.

[0048]

In Figs. 10 and 11, according to an ejection amount mode from an ejection amount mode information holding portion 213, a main pulse drive heater setter 214 sets the heater SH1, the heater SH2 or the heaters SH1 and SH2. Any one of drive waveform parameter setting tables 210A, 210B

and 210C corresponding to the main pulse drive heater set is selected. At the same time, the drive waveform parameter is output from the selected table on the basis of head temperature information.

[0049]

The combination of pre-heating pulse driven heaters for each ejection amount mode illustrated in Fig. 11 illustrates an example of the combination selected in such a manner as to correspond to the main pulse driven heater such selected as described above, and will be described in preferred embodiments below.

[0050]

(First Embodiment)

Figs. 12(a), 12(b) and 12(c) illustrate tables for setting a pre-pulse width P1 in the drive waveform parameter setting tables 210A, 210B and 210C (see Fig. 10) in a first embodiment according to the present invention. Furthermore, Figs. 13(a), 13(b) and 13(c) illustrate waveforms of heater driving pulses set by the main pulse driven heater setter 214 (see Fig. 10) and the above-described setting tables 210A, 210B and 210C in the present embodiment.

[0051]

As can be clear from these drawings, in the present embodiment, the heater SH1 as a smaller heater is used in the small ejection amount mode, the heater SH2 as a larger heater is used in the medium ejection amount mode, and both of the heaters SH1 and SH2 are used in the large ejection amount mode. Control for the pre-pulse width P1 according to the head temperature is also performed with respect to the heater which performs main heating (heater driving for generating bubbles).

[0052]

Furthermore, as illustrated in Fig. 12, the control of the pre-pulse width P1 according to the head temperature is to reduce the pulse width P1 as the detected head temperature is increased, as described above. Here, in the medium ejection amount mode, pre-heating is not performed when the head temperature is higher than or equal to 44 °C.

[0053]

Through the above-described control of the pre-pulse width, the ejection amount Vd0 in each ejection amount mode within the PWM control range (15 pl in the small ejection amount mode, 25 pl in the medium ejection amount mode and 40 pl in the large ejection amount mode), as illustrated in Fig.

8, can be stabilized within substantially the constant range. It should be noted that, at the head temperature lower than or equal to 26 °C (T_0 illustrated in Fig. 8) in the present embodiment, the head temperature is controlled by means of the temperature adjusting heater provided in the ink-jet head for the purpose of stability of the ejection amount Vd.

[0054]

(Second Embodiment)

Figs. 14(a), 14(b) and 14(c) illustrate tables of a pre-pulse width P1 in a second embodiment according to the present invention. Fig. 15 illustrates drive pulse waveforms. As illustrated in these drawings, a difference from the above-mentioned first embodiment resides in the pre-pulse width control in the medium ejection amount mode and the large ejection amount mode.

[0055]

More specifically, in the medium ejection amount mode, the pre-pulse is applied to not only the large heater SH2 but also the small hater SH1. Here, within the temperature range of 26 °C to 46 °C, the pre-pulse width P1 of the small heater SH1 is fixed (1 μsec), and in contrast, the pre-pulse width P1 of the large heater is controlled to become narrower with an increase in head

temperature. Within the temperature range higher than or equal to 46 °C, the pre-pulse width P1 of the large heater is set to be zero, and in contrast, the pre-pulse width P1 of the small heater is controlled to become narrower with an increase in head temperature.

[0056]

In the medium ejection amount mode, despite of the fact that the main (heating) pulse is applied only to the large heater SH2, the pre-pulse is applied to drive both of the small and large heaters. Thus, the temperature range for ejection amount stabilizing control can be widened. By this, the ejection amount in the medium ejection amount mode becomes 28 pl, and thus, can be slightly greater than 25 pl in the first embodiment.

[0057]

In addition, in the large ejection amount mode, both of the small heater SH1 and the large heater SH2 are used. However, the pre-pulse width is controlled in a manner similar to in the above-described medium ejection amount mode.

[0058]

(Third Embodiment)

Figs. 16 and 17 illustrate tables of pre-pulse widths P1 in a third embodiment according to

the present invention, and Fig. 18 illustrates waveforms of drive pulses in the present embodiment.

[0059]

In the present embodiment, the tables of the pre-pulses P1 are switched for low temperatures or high temperatures according to the head temperature at the beginning of printing. For this purpose, the tables for low temperatures and high temperatures are provided for respective ejection amount modes. Fig. 16 illustrates the tables for low temperatures in the small ejection amount mode and the medium ejection amount mode, respectively, wherein the tables for high temperatures in these modes are similar to those illustrated in Figs. 12(a) and 12(b). Further, Fig. 17 illustrates the table for low temperatures and the table for high temperatures in the large ejection amount mode.

[0060]

As can be appreciated from these drawings and Fig. 18, the pre-heating pulse is applied to the large heater in the low temperature mode, and to the small heater in the high temperature mode.

[0061]

In the present embodiment, since pre-heating is performed by the heater different from the

heater for the main-heating in the low temperature mode, few influence can be exerted on bubbles in the main heating even if the bubbles are previously generated by driving a pulse having a slightly greater width as long as the amount of the bubbles is quite small.

[0062]

In addition, since the pre-heating is performed by the different heater or not so much consideration is taken to the influence of the bubbles, the interval (the quiescent period) between the pre-pulse and the main pulse can be shortened. Furthermore, the temperature adjusting means for the head becomes substantially unnecessary by providing the low temperature mode.

[0063]

Moreover, in the present embodiment, it becomes unnecessary to switch the heater for applying the pre-pulse within at least a page being printed by providing the two tables for the head temperatures in the overlapping manner. Therefore, it is possible to prevent any seaming streak on an image caused by a difference of density which may be caused by switching of the heater.

[0064]

(Fourth Embodiment)

Figs. 19(a) to 19(c) illustrate off time tables for ejection amount modes in a fourth embodiment according to the present invention, and Figs. 20(a) to 20(c) illustrate waveforms of drive pulses.

[0065]

In the present embodiment, as can be clear from Figs. 19 and 20, like the first embodiment, a small heater SH1 is used in a small ejection amount mode, a large heater SH2 is used in a medium ejection amount mode, and the small and large heaters SH1 and SH2 are used in a large ejection amount mode.

[0066]

However, unlike the first embodiment, in the present embodiment, an ejection amount is stabilized by controlling the quiescent period (off time) P2. Namely, the off time P2 is varied while a pre-pulse width P1 is kept to be fixed by utilizing the fact that a longer off time P2 results in a greater ejection amount.

Specifically, the off time P2 is shortened with an increase in head temperature; to the contrary, the off time P2 is lengthened with a decrease in head temperature.

[0067]

Like the pre-pulse width, since the temperature dependency of the ejection amount and the dependency on the off time P2 are different in each of the ejection amount modes, the ejection amount can be stabilized in each ejection amount mode by setting the off time P2 corresponding to each of the ejection amount modes.

[0068]

(Fifth Embodiment)

Fig. 21 illustrates tables of the off time P2 similar to the above-described fourth embodiment, and Fig. 22 illustrates waveforms of the drive pulses.

[0069]

In the present embodiment, similarly to the above-described fourth embodiment, the off time P2 is controlled to stabilize the ejection amount. The manner of the off time control is somewhat varied according to ejection amount modes.

[0070]

More specifically, in a small ejection amount mode and a medium ejection amount mode, pre-heating is performed by using a heater other than a heater for main heating. In this case, a longer off time P2 results in a larger ejection amount. Therefore, the off time P2 is controlled to be

shortened according to an increase in head temperature. In the case of such control, since a pre-pulse P1 and a main pulse P3 for the same heater do not form a double pulse, it is possible to also set the pre-pulse P1 and the main pulse P3 in such a manner as to overlap on a time axis.

[0071]

Further, when the off time P2 of the double pulse for the same heater is shortened, the double pulse can become a single pulse at last. Even before establishing the single pulse, the pre-pulse P1 and the main-pulse P3 are connected due to a slight delay in falling-down of the rectangular wave despite of the presence of the off time to form a single pulse having a greater pulse width. Such problem can be avoided in the present embodiment.

[0072]

Next, although in a large ejection amount mode, the large heater and the small heater apply the double pulse waveform, the off time of one of the heaters is made variable to control the timing of the main pulse to shift a bubbling timing.

[0073]

This utilizes the fact that the ejection amount becomes smaller by the shift of the bubbling timings of the plurality of heaters.

Then, only control of an off time P2 make it possible to shift the bubbling timings, in the same manner as control of the ejection amount.

[0074]

(Other Embodiments)

The foregoing embodiments have been discussed in the construction in which the plurality of heaters are laterally arranged for one ejection opening, as shown in Fig. 4. However, similar advantageous results can be produced by a configuration in which heaters are longitudinally arranged, as shown in Fig. 23. Alternatively, similar advantageous results can also be produced in a head construction in which ink droplets are ejected upward with respect to a heater surface.

[0075]

In addition, while the description has been given of the case where the heaters are different in size, similar advantageous results can be produced in the case where the heaters are the same in size. However, in the case of the heaters having the same size, there are basically two ejection amount modes, i.e., a large ejection amount mode and a small ejection amount mode.

[0076]

Although no particular description has been given in the foregoing embodiments, it is

preferred that the distance between the heaters should be as short as possible. In the second, third and fifth embodiments, the advantageous results will become more remarkable.

[0077]

Furthermore, while the discussion has been given of varying the parameter such as the pre-pulse width P1 according to the head temperature, a more stable ejection amount can be obtained by setting the target temperature according to the environmental temperature and varying the parameter according to the difference between the head temperature and the target temperature. Namely, even when the environmental temperature is different even at the same head temperature, the ink temperature is basically close to the environmental temperature, including a supply system.

[0078]

(Others)

According to the present invention, particularly among the ink-jet recording systems, the excellent effects can be produced in the recording head or apparatus of the system provided with the means for generating thermal energy (e.g., an electrothermal transducer, a laser beam or the like) as energy utilized for performing the ink

ejection so as to induce the ink state variation caused by the thermal energy, thus achieving high density and high fineness of recording.

[0079]

It is preferable that the basic principle disclosed in, e.g., U.S. Patent No. 4,723,129 or 4,740,796 should be used for the typical configuration and principle of the above-described apparatus. This system can be applicable to either an on-demand type or a continuous type. Particularly, the on-demand type is effective because at least one drive signal for rapidly increasing a temperature in excess of a film boiling point in response to recording information is applied to the electrothermal transducer arranged in a manner corresponding to a sheet holding liquid (ink) thereon or a liquid path, thereby generating thermal energy in the electrothermal transducer so as to generate film boiling at a heat acting surface of the recording head, resulting in formation of bubbles in the liquid (ink) in one-to-one correspondence to the drive signal. Growth or contraction of the bubbles causes the liquid (ink) to be ejected through the ejection opening, thus forming at least one droplet. The drive signal in the form of a pulse is much preferable because the bubbles

can grow or be contracted instantaneously and appropriately, and thus, the liquid (ink) can be ejected with remarkably high responsiveness. A signal disclosed in U.S. Patent No. 4,463,359 or 4,345,262 may be suitable for the drive signal in the form of a pulse. More excellent recording can be achieved by using conditions disclosed in U.S. Patent No. 4,313,124 relating to a temperature increasing rate at the heat acting surface.

[0080]

The configurations of the recording heads according to the present invention include the configuration disclosed in U.S. Patent No. 4,558,333 or 4,459,600 in which the heat acting surface is located in a bent region beside the configuration in which the ejection openings, the liquid paths and the electrothermal transducers are combined with each other (a linear liquid channel or a rectangular liquid channel) as disclosed in the aforementioned specifications. Additionally, the effect according to the present invention may be produced in the configuration disclosed in Japanese Patent Application Laid-open No. 123,670/1984 in which slots common to a plurality of electrothermal transducers are used as ejection openings of the electrothermal transducers, or in the configuration disclosed in

Japanese Patent Application Laid-open No. 138,461/1984 in which openings for absorbing a pressure wave of thermal energy correspond to ejection openings. That is, recording operation may be securely performed with efficiency according to the present invention irrespective of whatever the configuration of the recording head is.

[0081]

Furthermore, the recording head of a full-line type having a length corresponding to the maximum width of the recording medium which can be recorded by the recording apparatus may take either one of the configuration in which a plurality of recording heads are combined to cover the length and the configuration of one recording head formed integrally.

[0082]

Additionally, there may be used not only the recording head of the cartridge type in which an ink tank is disposed integrally with the recording head per se, as described in the above embodiment, but also a recording head of a replaceable chip type in which the head is fixed to the apparatus body to be electrically connected to the apparatus body or ink can be supplied from the apparatus body.

[0083]

It is preferable that ejection recovering means, preliminarily auxiliary means or the like for the recording head should be additionally disposed as constituents of the recording apparatus according to the present invention, thus further stabilizing the advantageous results of the present invention. There are specifically listed capping means with respect to the recording head, cleaning means, pressurizing or sucking means, preliminarily heating means for performing heating by the use of the thermoelectric transducer, other heating elements, or the combination thereof, and preliminarily ejecting means for performing ejection other than recording.

[0084]

With respect to the kind or number of recording heads to be installed, only one recording head may be provided in a fashion corresponding to monochromatic ink, or a plurality of recording heads may be provided in a fashion corresponding to a plurality of inks different in color or concentration. That is, the present invention can be effectively applicable to recording apparatuses in not only a recording mode in only one main color such as black but also a full-color recording mode in different or mixed

colors by using either an integral ink-jet head or a plurality of recording heads in combination.

[0085]

Although the ink in the state of liquid has been explained in the above-described embodiments according to the present invention, there may be used ink which is solidified at room temperature or lower and softened or liquefied at room temperature. Otherwise, since in the ink-jet system, the temperature of the ink is generally controlled so as to keep the viscosity of the ink within a stable ejection range by adjusting the temperature of the ink per se within the range from 30 °C to 70 °C, there may be used ink which becomes liquefied at the time of application of a used recording signal. Additionally, ink which is solid in a left state while is liquefied by heating may be used in order to aggressively prevent an increase in temperature due to thermal energy which is used as energy for transforming the ink from solid to liquid, or to prevent any evaporation of the ink. Anyway, the present invention is applicable to the case using ink having a property which is first liquefied with application of thermal energy, such as ink which is liquefied with application of thermal energy in response to a print signal to be ejected in a

liquid state, ink which has started to be solidified already at the time when it reaches a medium to be printed, or the like. As disclosed in Japanese Patent Application Laid-open No. 56847/1979 or 71260/1985, such ink may be disposed opposite to the thermoelectric transducer in a manner held in a liquid or solid state in a recess or through hole formed at a porous sheet.

According to the present invention, the above-described film boiling system is most effective for each of the above-described inks.

[0086]

Furthermore, the ink-jet recording apparatus according to the present invention may be used as an image output terminal for information processing equipment such as a computer, a copy machine combined with a reader, a facsimile apparatus having a transmitting/receiving function, or the like.

[0087]

[Advantageous Results of the Invention]

As described above, according to the present invention, the heaters can be controlled to be driven in each of combinations of the heaters set to be driven out of the plurality of heaters, and thus, the pre-pulses to be applied for stabilizing

the ejection amount can be controlled in each of the combinations.

[0088]

Consequently, it is possible to stably control the ejection amount so as to obtain the image of high quality.

[BRIEF DESCRIPTION OF THE DRAWINGS]

[Fig. 1]

Fig. 1 is a perspective view showing an ink-jet printing apparatus in a first embodiment according to the present invention.

[Fig. 2]

Fig. 2 is a block diagram illustrating mainly a control system of the printing apparatus.

[Fig. 3]

Fig. 3 is a cross-sectional view showing an ink-jet head and an ink tank cartridge for use in the apparatus.

[Fig. 4]

Fig. 4 is a cross-sectional view showing the structure of an ink-jet head in a first preferred embodiment according to the present invention.

[Fig. 5]

Fig. 5 is a graph illustrating the head temperature dependency of an ink ejection amount in each ejection mode in the preferred embodiment according to the present invention.

[Fig. 6]

Fig. 6 schematically illustrates waveforms of pre-pulses to be used in the embodiment according to the present invention.

[Fig. 7]

Fig. 7 is a graph illustrating the relationship between a pre-pulse width and the ejection amount in each of ink ejection modes in the embodiment according to the present invention.

[Fig. 8]

Fig. 8 is a graph illustrating a manner of ejection amount control in the embodiment according to the present invention.

[Fig. 9]

Fig. 9 is a block diagram illustrating the construction of heater driving in the embodiment according to the present invention.

[Fig. 10]

Fig. 10 is a block diagram illustrating a further construction of heater driving in the preferred embodiment according to the present invention.

[Fig. 11]

Fig. 11 illustrates the relationship between ejection amount modes and main pulse and pre-pulse driven heaters in some embodiments according to the present invention.

[Fig. 12]

Figs. 12(a) to 12(c) schematically illustrate tables of pre-pulses P1 in each of the ejection amount modes in a first embodiment according to the present invention.

[Fig. 13]

Figs. 13(a) to 13(c) illustrate waveforms of drive pulses in the first embodiment.

[Fig. 14]

Figs. 14(a) to 14(c) schematically illustrate tables of pre-pulses P1 in each of the ejection amount modes in a second embodiment according to the present invention.

[Fig. 15]

Figs. 15(a) to 15(c) illustrate waveforms of drive pulses in the second embodiment.

[Fig. 16]

Figs. 16(a) and 16(b) schematically illustrate tables of pre-pulses P1 in each of the ejection amount modes in a third embodiment according to the present invention.

[Fig. 17]

Figs. 17(a) and 17(b) schematically illustrate tables of pre-pulses P1 in each of the ejection amount modes in the third embodiment according to the present invention.

[Fig. 18]

Figs. 18(a) to 18(c) illustrate waveforms of drive pulses in the third embodiment.

[Fig. 19]

Figs. 19(a) to 19(c) schematically illustrate tables of pre-pulses P1 in each of the ejection amount modes in a fourth embodiment according to the present invention.

[Fig. 20]

Figs. 20(a) to 20(c) illustrate waveforms of drive pulses in the fourth embodiment.

[Fig. 21]

Figs. 21(a) to 21(c) schematically illustrate tables of pre-pulses P1 in each of the ejection amount modes in a fifth embodiment according to the present invention.

[Fig. 22]

Figs. 22(a) to 22(c) illustrate waveforms of drive pulses in the fifth embodiment.

[Fig. 23]

Fig. 23 is a cross-sectional view showing the structure of an ink-jet head in another embodiment according to the present invention.

[Fig. 24]

Fig. 24 is a cross-sectional view showing the structure of an ink-jet head in a further embodiment according to the present invention.

[REFERENCE NUMERALS]

2, 2Y, 2M, 2C, 2Bk ... ink-jet head

2A ... ink path

2N ... ejection opening

200 ... controller

SH1, SH2 ... heater

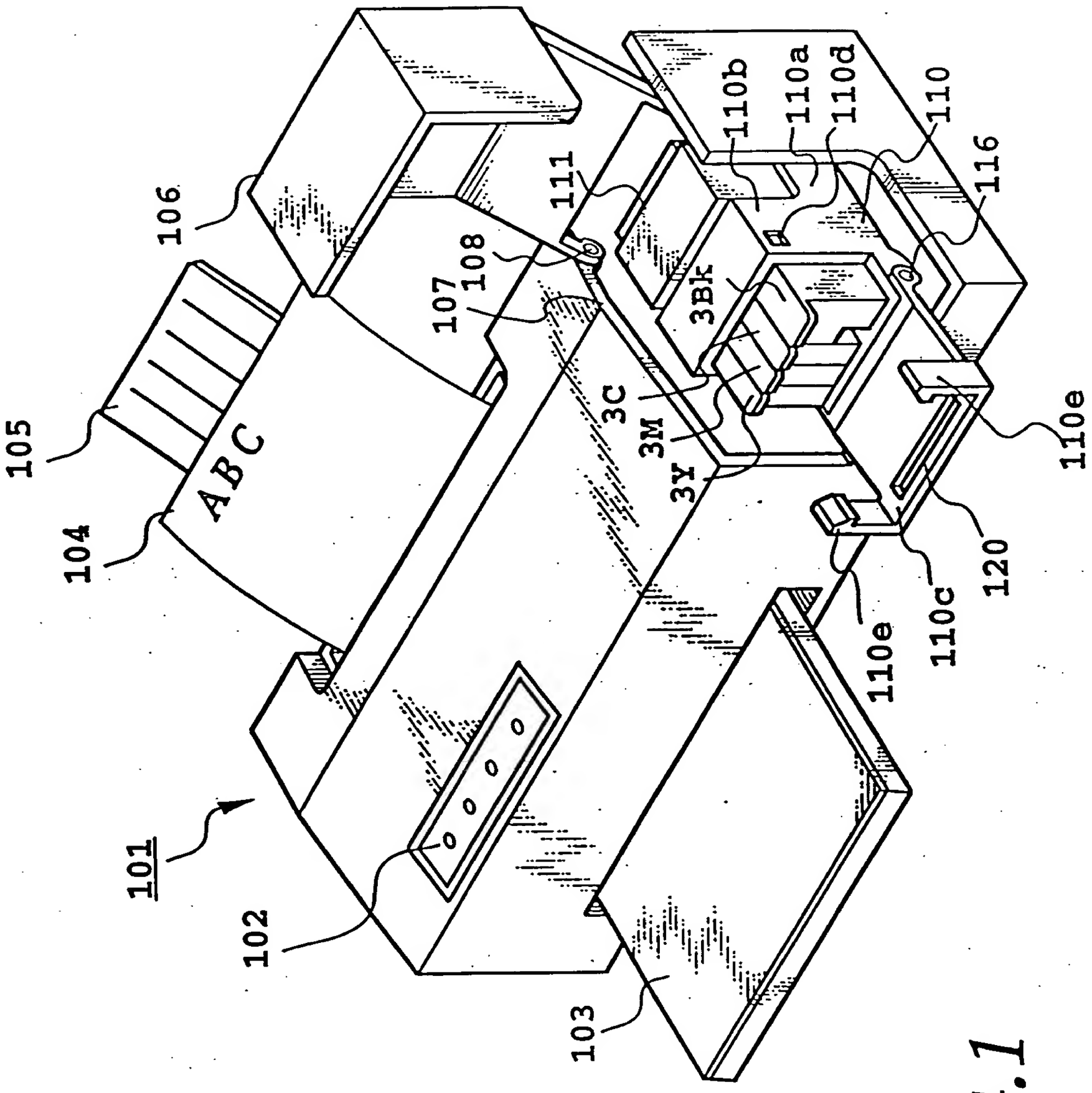

106
105
104
ABC
107
108
111
3C
3M
3Y
3Bk
110b
110a
110d
110
116
110e
110c
120
110e
101
102
103

FIG. 1

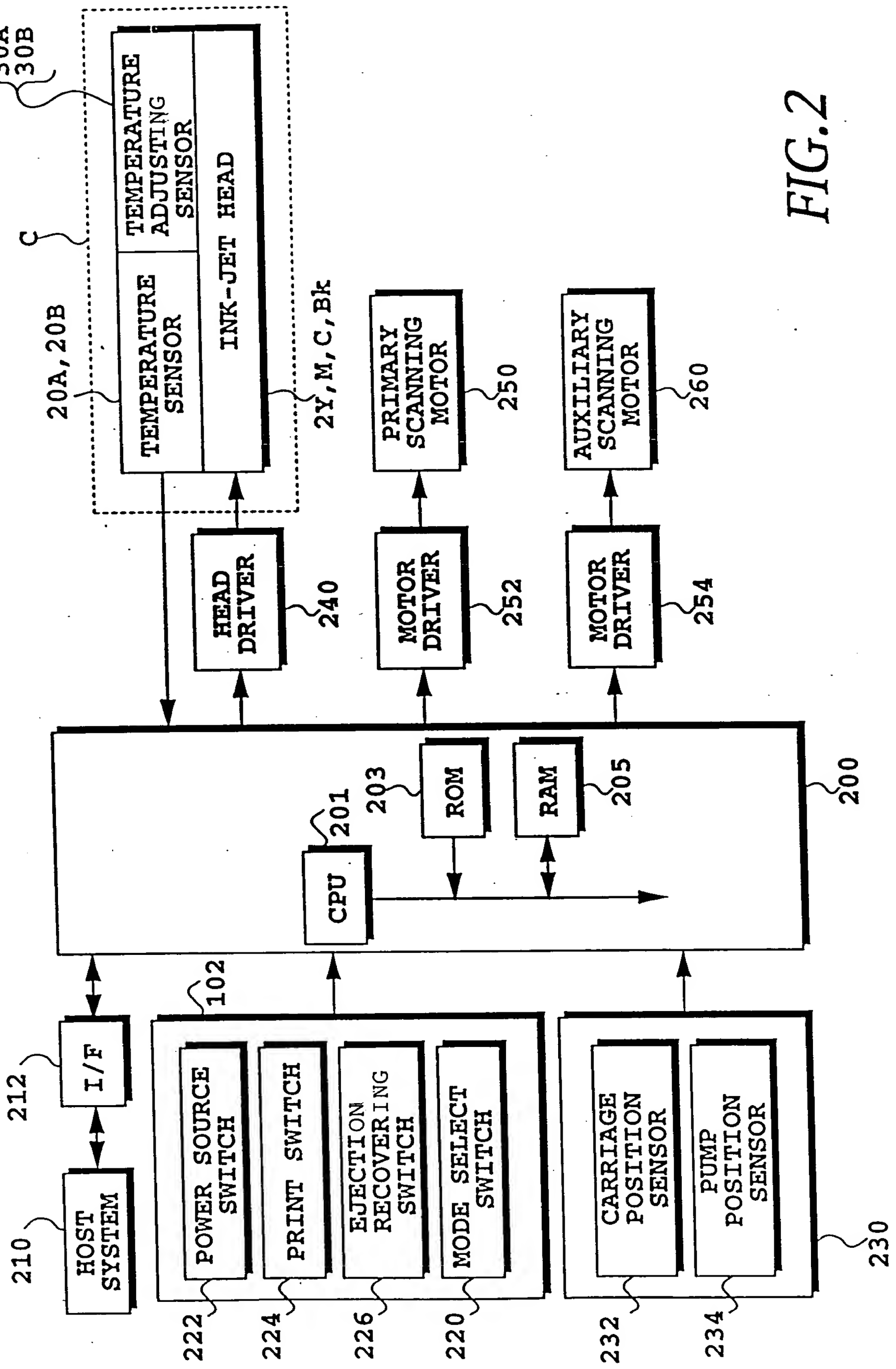

30A
30B
C
20A, 20B
TEMPERATURE ADJUSTING SENSOR
TEMPERATURE SENSOR
INK-JET HEAD
2Y, M, C, Bk
PRIMARY SCANNING MOTOR
250
AUXILIARY SCANNING MOTOR
260
HEAD DRIVER
240
MOTOR DRIVER
252
MOTOR DRIVER
254
CPU
201
203
ROM
RAM
205
200
102
212
I/F
210
HOST SYSTEM
POWER SOURCE SWITCH
PRINT SWITCH
EJECTION RECOVERING SWITCH
MODE SELECT SWITCH
222
224
226
220
CARRIAGE POSITION SENSOR
PUMP POSITION SENSOR
232
234
230

FIG.2

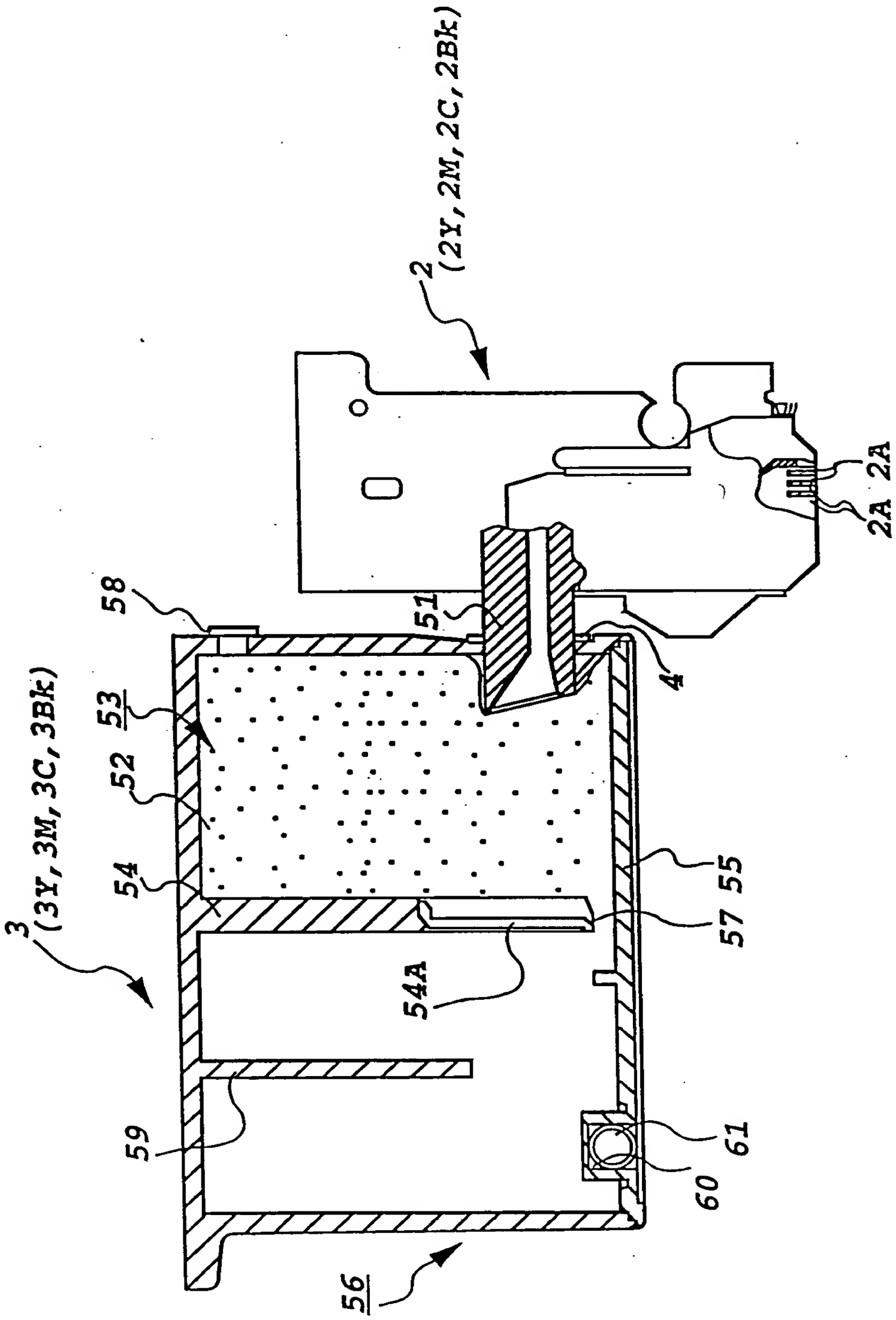

2
(2Y, 2M, 2C, 2Bk)
2A 2A
58
51
4
53
52
54
3
(3Y, 3M, 3C, 3Bk)
57 55
54A
59
61
60
56

FIG.3

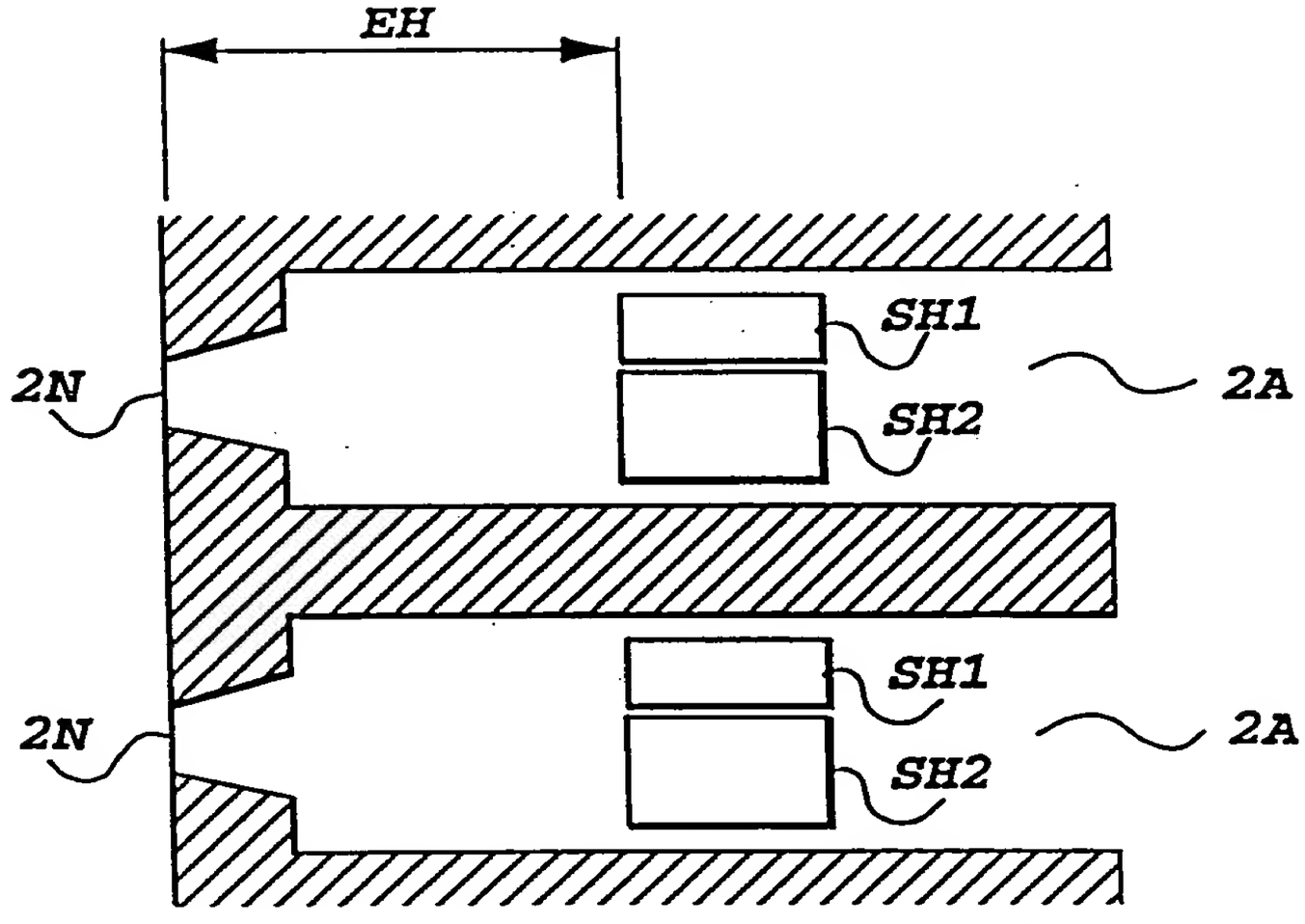


FIG. 4

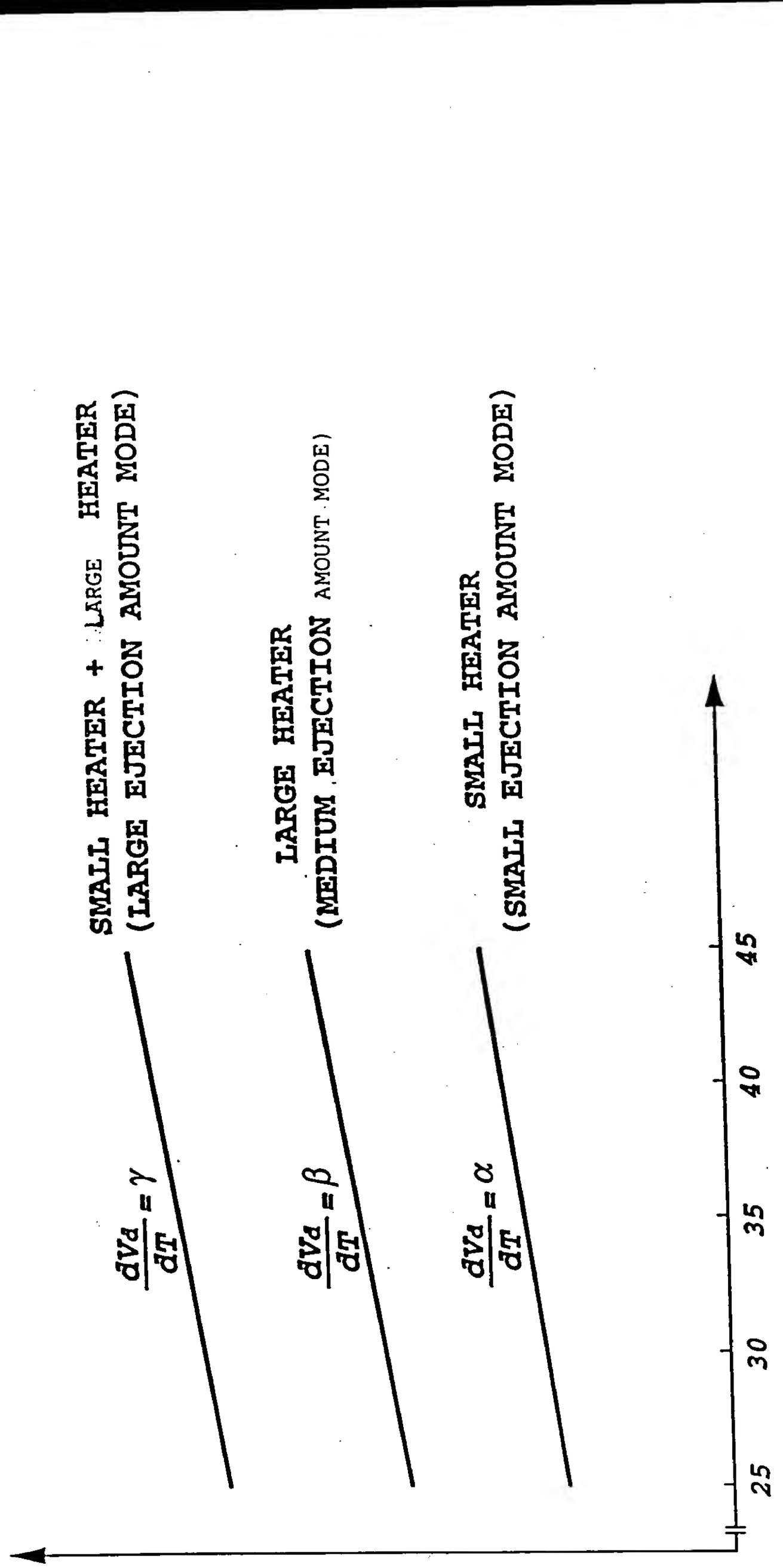

SMALL HEATER + LARGE HEATER
(LARGE EJECTION AMOUNT MODE)
LARGE HEATER
(MEDIUM EJECTION AMOUNT MODE)
SMALL HEATER
(SMALL EJECTION AMOUNT MODE)
$\frac{dVd}{dT} = \gamma$
$\frac{dVd}{dT} = \beta$
$\frac{dVd}{dT} = \alpha$
25
30
35
40
45
HEAD TEMPERATURE T_h (°C)
EJECTION AMOUNT V_d (pl)

FIG. 5

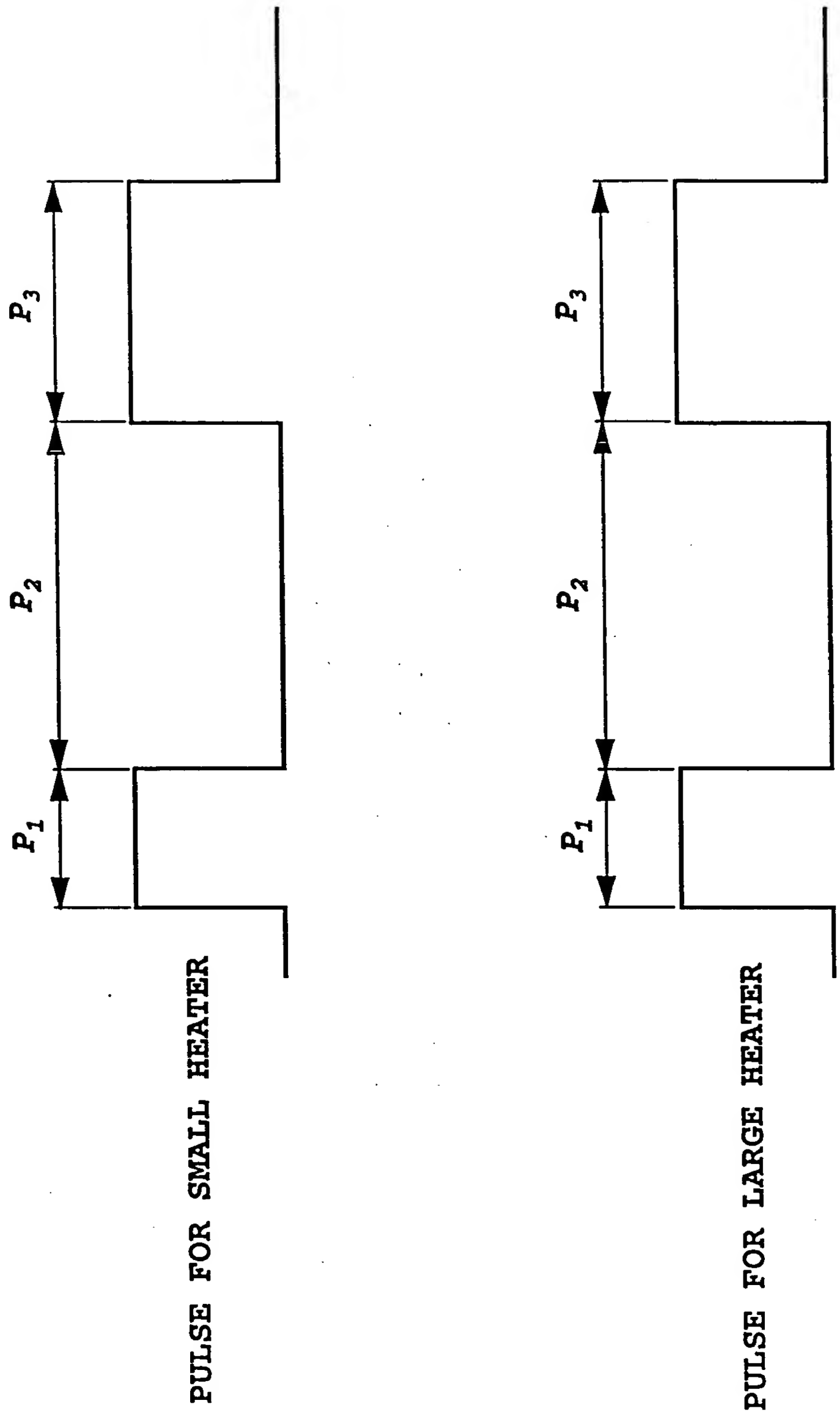

P_3
P_2
P_1
HEATER
PULSE FOR SMALL
P_3
P_2
P_1
HEATER
PULSE FOR LARGE

FIG. 6

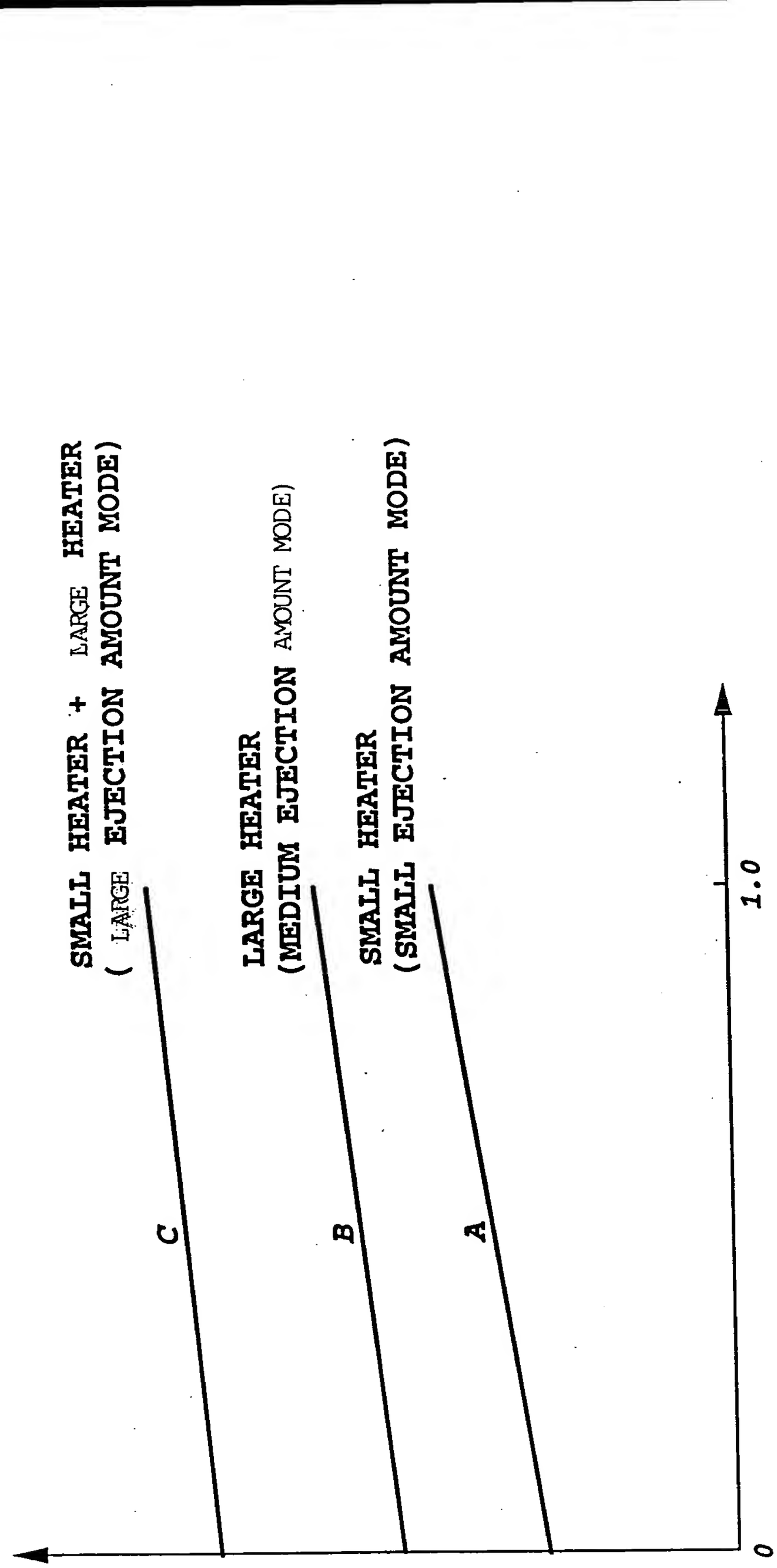

SMALL HEATER + LARGE HEATER
(LARGE EJECTION AMOUNT MODE)
LARGE HEATER
(MEDIUM EJECTION AMOUNT MODE)
SMALL HEATER
(SMALL EJECTION AMOUNT MODE)
C
B
A
1.0
0
PRE-PULSE WIDTH P1 (μsec)
EJECTION AMOUNT Vd (pl)

FIG. 7

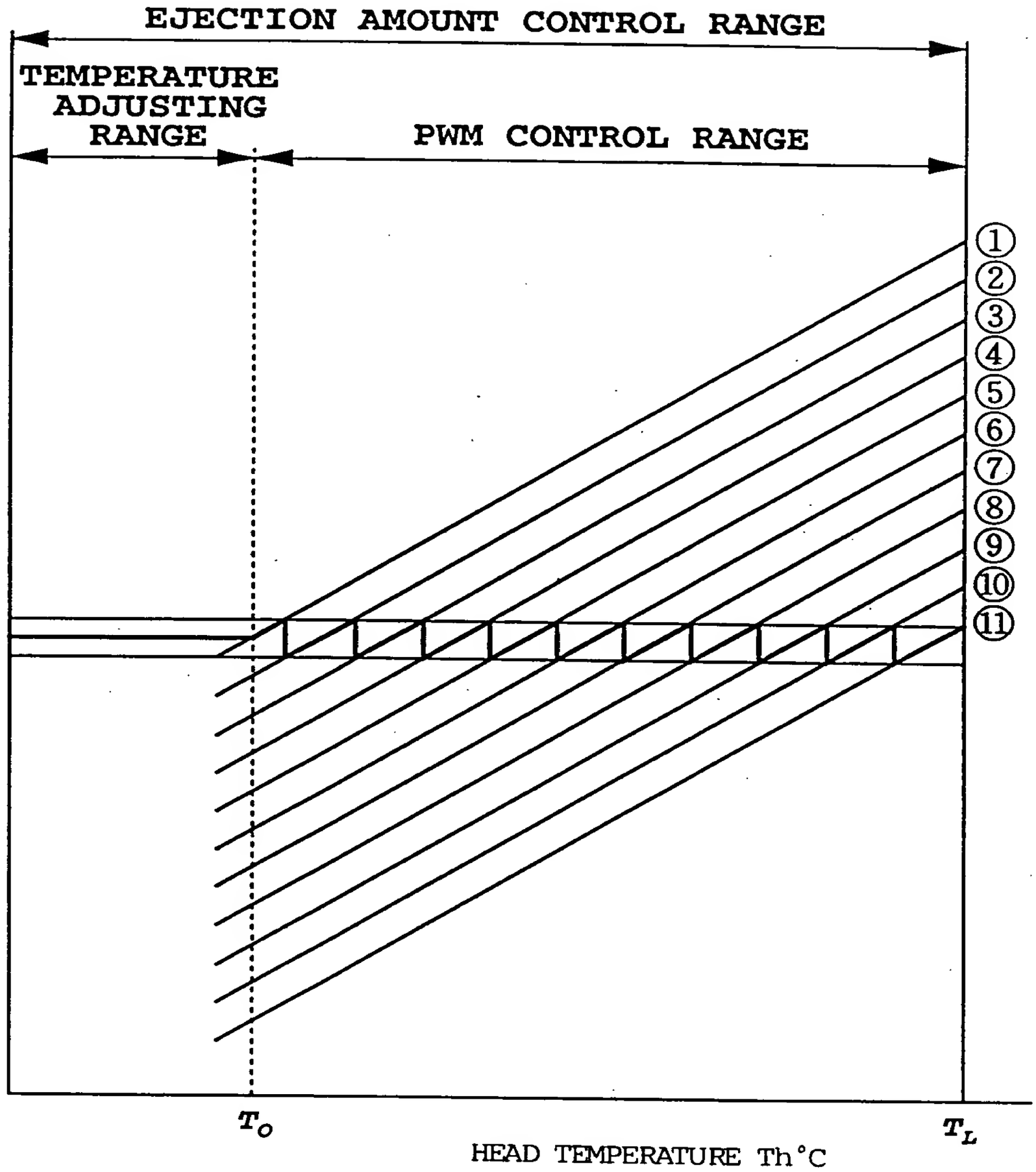

EJECTION AMOUNT CONTROL RANGE
TEMPERATURE ADJUSTING RANGE
PWM CONTROL RANGE
①
②
③
④
⑤
⑥
⑦
⑧
⑨
⑩
⑪
EJECTION AMOUNT V_{do} (pl)
T_o
T_L
HEAD TEMPERATURE Th°C

FIG. 8

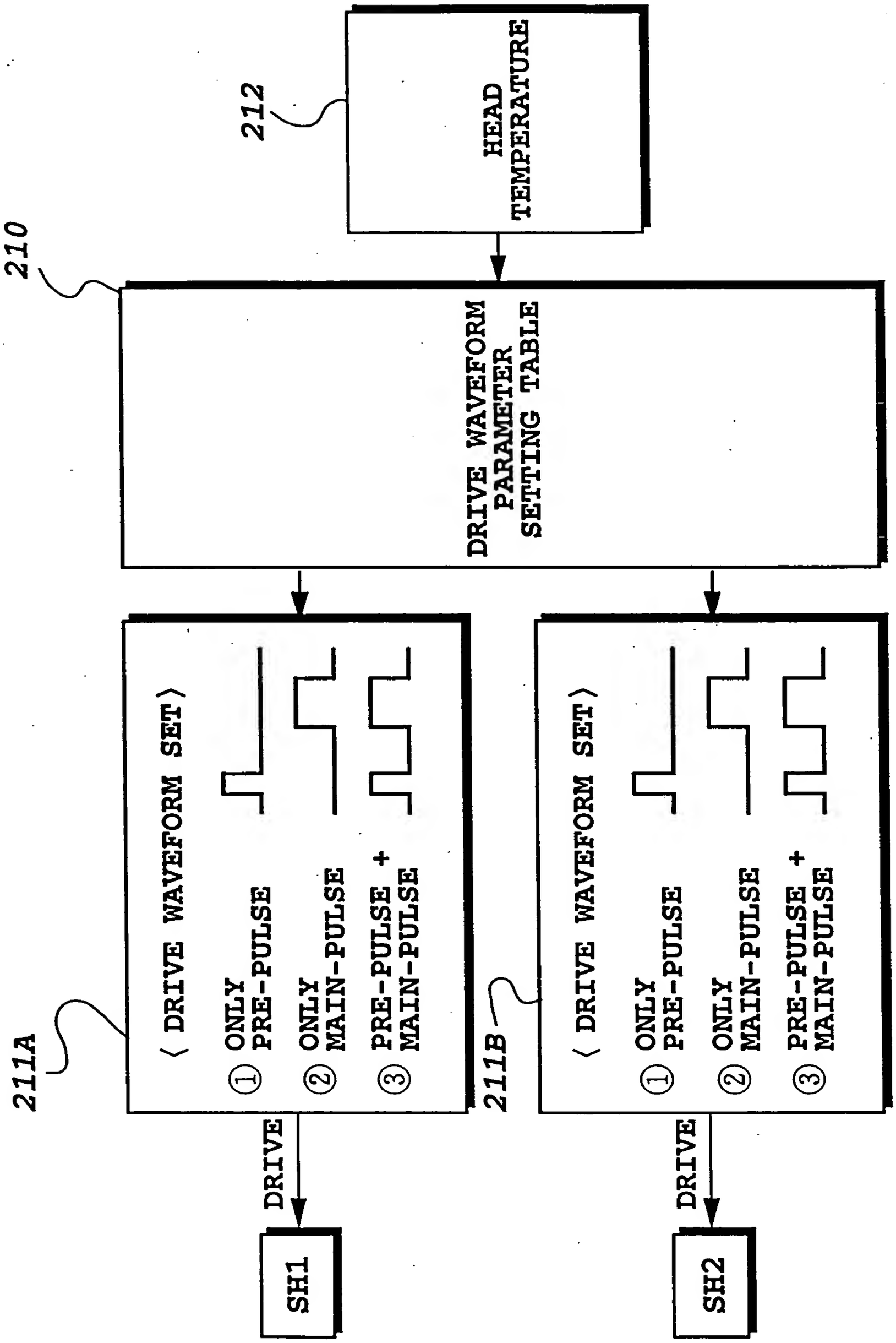

212
HEAD TEMPERATURE
210
DRIVE WAVEFORM PARAMETER SETTING TABLE
211A
〈 DRIVE WAVEFORM SET〉
① ONLY PRE-PULSE
② ONLY MAIN-PULSE
③ PRE-PULSE + MAIN-PULSE
DRIVE
SH1
211B
〈 DRIVE WAVEFORM SET〉
① ONLY PRE-PULSE
② ONLY MAIN-PULSE
③ PRE-PULSE + MAIN-PULSE
DRIVE
SH2

FIG. 9

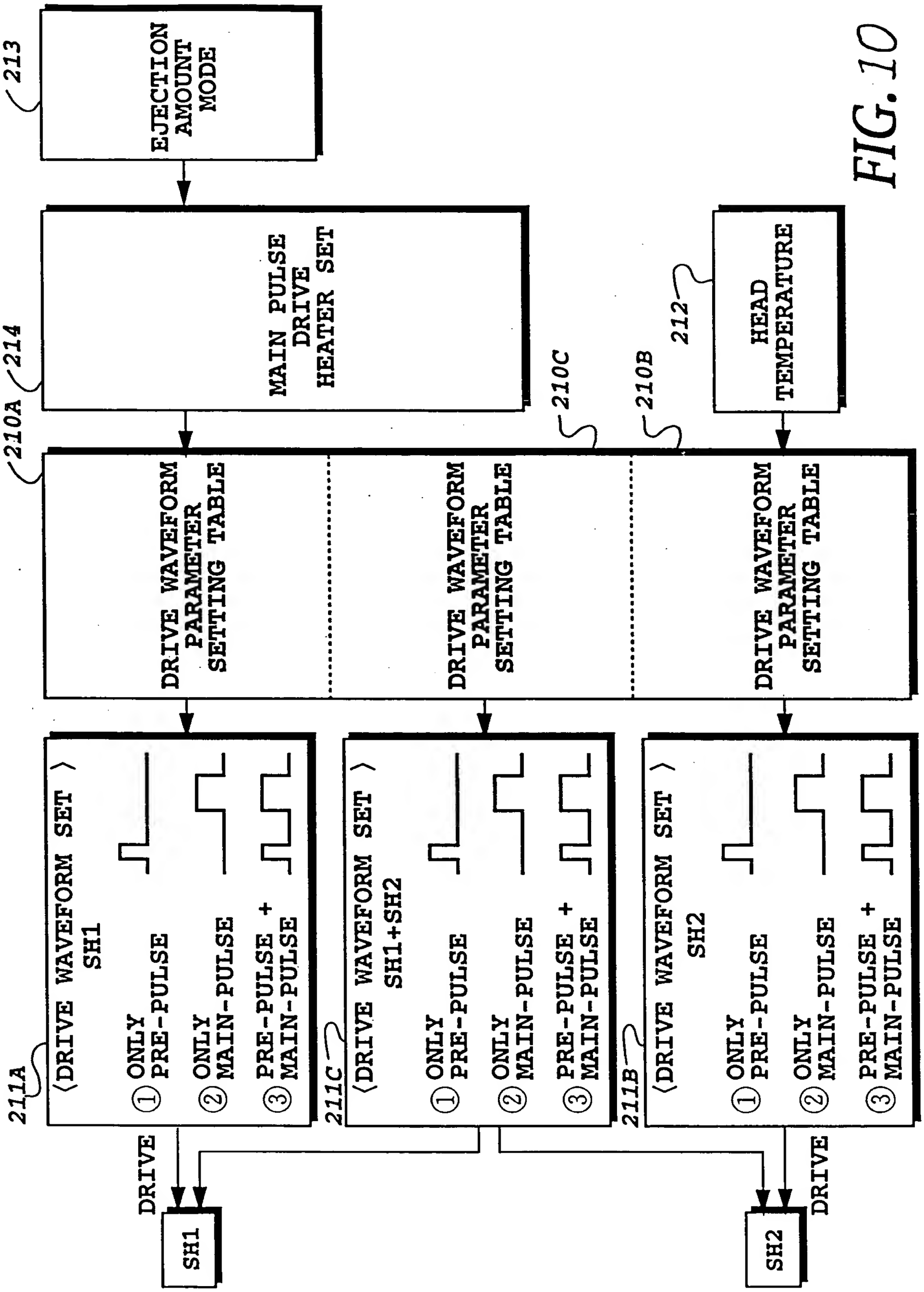

213
EJECTION AMOUNT MODE
214
MAIN PULSE DRIVE HEATER SET
210A
210C
210B
212
HEAD TEMPERATURE
DRIVE WAVEFORM PARAMETER SETTING TABLE
DRIVE WAVEFORM PARAMETER SETTING TABLE
DRIVE WAVEFORM PARAMETER SETTING TABLE
211A
〈DRIVE WAVEFORM SET〉
SH1
① ONLY PRE-PULSE
② ONLY MAIN-PULSE
③ PRE-PULSE + MAIN-PULSE
211C
〈DRIVE WAVEFORM SET〉
SH1+SH2
① ONLY PRE-PULSE
② ONLY MAIN-PULSE
③ PRE-PULSE + MAIN-PULSE
211B
〈DRIVE WAVEFORM SET〉
SH2
① ONLY PRE-PULSE
② ONLY MAIN-PULSE
③ PRE-PULSE + MAIN-PULSE
DRIVE
SH1
DRIVE
SH2

FIG. 10

214

EJECTION AMOUNT MODE (213)	MAIN HEATING PULSE DRIVEN HEATER	PRE-HEATING PULSE DRIVEN HEATER
SMALL	SH1	SH1
		SH2
		SH1+SH2
MEDIUM	SH2	SH1
		SH2
		SH1+SH2
LARGE	SH1+SH2	SH1
		SH2
		SH1+SH2

FIG. 11

FIG. 12

(a) P_1 TABLE FOR SMALL EJECTION AMOUNT MODE (15pl)

HEAD TEMPERATURE T (℃)	~26	~28	~30	~32	~34	~36	~38	~40	~42	~44	~46	~48	~50	~52	~54	~56	~58	~60	60~
SMALL HEATER PRE-PULSE (μsec)	1.0	0.95	0.90	0.85	0.80	0.75	0.70	0.65	0.60	0.55	0.50	0.45	0.40	0.35	0.30	0.25	0.20	0.15	0.10
LARGE HEATER PRE-PULSE (μsec)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

(b) P_1 TABLE FOR MEDIUM EJECTION AMOUNT MODE (25pl)

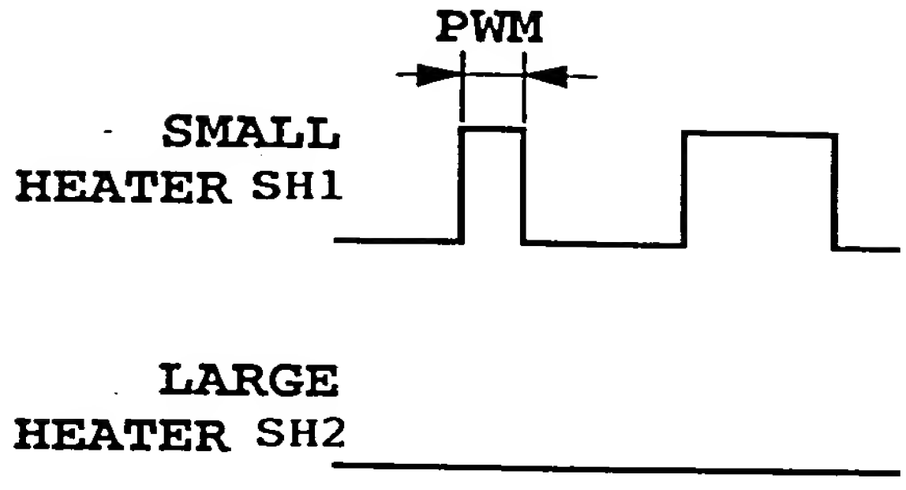
HEAD TEMPERATURE T (℃)	~26	~28	~30	~32	~34	~36	~38	~40	~42	~44	~46	~48	~50	~52	~54	~56	~58	~60	60~
SMALL HEATER PRE-PULSE (μsec)	1.0	0.9	0.8	0.7	0.6	0.5	0.4	0.3	0.2	0.1	0	0	0	0	0	0	0	0	0
LARGE HEATER PRE-PULSE (μsec)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

(c) P_1 TABLE FOR LARGE EJECTION AMOUNT MODE (40pl)

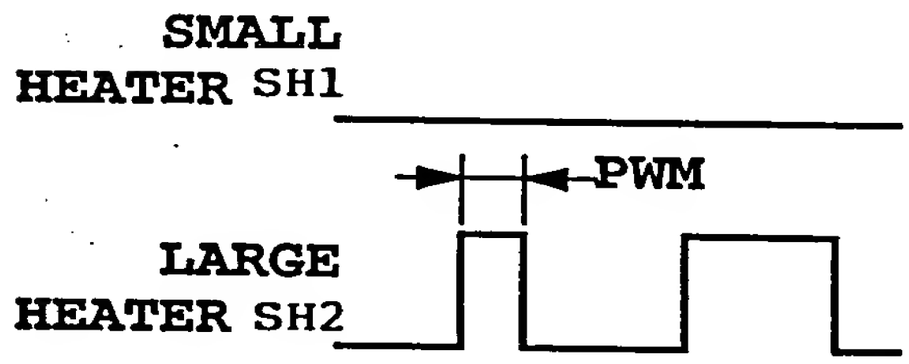
HEAD TEMPERATURE T (℃)	~26	~28	~30	~32	~34	~36	~38	~40	~42	~44	~46	~48	~50	~52	~54	~56	~58	~60	60~
SMALL HEATER PRE-PULSE (μsec)	1.0	0.95	0.90	0.85	0.80	0.75	0.70	0.65	0.60	0.55	0.50	0.45	0.40	0.35	0.30	0.25	0.20	0.15	0.10
LARGE HEATER PRE-PULSE (μsec)	1.0	0.95	0.90	0.85	0.80	0.75	0.70	0.65	0.60	0.55	0.50	0.45	0.40	0.35	0.30	0.25	0.20	0.15	0.10

FIG. 13

(a) (FOR SMALL EJECTION AMOUNT MODE)



(b) (FOR MEDIUM EJECTION AMOUNT MODE)



(c) (FOR LARGE EJECTION AMOUNT MODE)

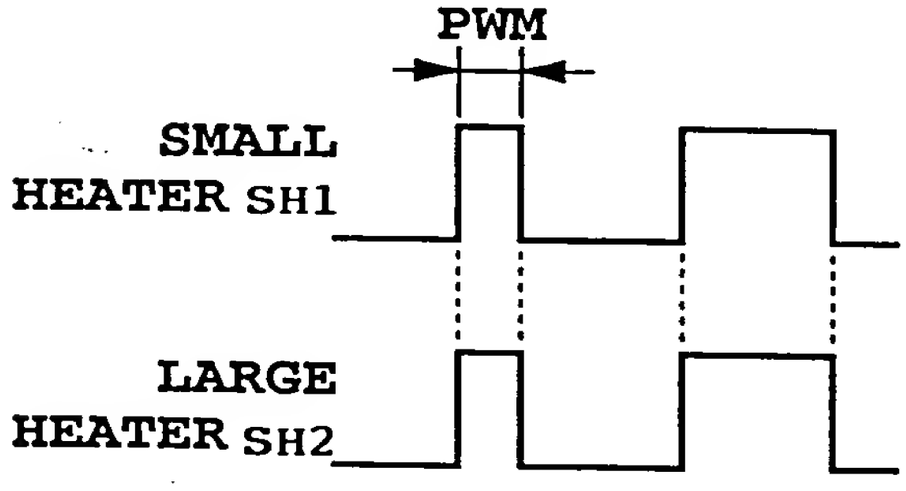


FIG. 14

(a)

P_1 TABLE FOR SMALL EJECTION AMOUNT MODE (15pl)

HEAD TEMPERATURE T (°C)	~26	~28	~30	~32	~34	~36	~38	~40	~42	~44	~46	~48	~50	~52	~54	~56	~58	~60	60~
SMALL HEATER PRE-PULSE (μsec)	1.0	0.95	0.90	0.85	0.80	0.75	0.70	0.65	0.60	0.55	0.50	0.45	0.40	0.35	0.30	0.25	0.20	0.15	0.10
LARGE HEATER PRE-PULSE (μsec)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

(b)

P_1 TABLE FOR MEDIUM EJECTION AMOUNT MODE (25pl)

HEAD TEMPERATURE T (°C)	~26	~28	~30	~32	~34	~36	~38	~40	~42	~44	~46	~48	~50	~52	~54	~56	~58	~60	60~
SMALL HEATER PRE-PULSE (μsec)	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	0.8	0.6	0.4	0.2	0	0	0	0
LARGE HEATER PRE-PULSE (μsec)	1.0	0.9	0.8	0.7	0.6	0.5	0.4	0.3	0.2	0.1	0	0	0	0	0	0	0	0	0

(c)

P_1 TABLE FOR LARGE EJECTION AMOUNT MODE (40pl)

HEAD TEMPERATURE T (°C)	~26	~28	~30	~32	~34	~36	~38	~40	~42	~44	~46	~48	~50	~52	~54	~56	~58	~60	60~
SMALL HEATER PRE-PULSE (μsec)	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	0.9	0.8	0.7	0.6	0.5	0.4	0.3	0.2
LARGE HEATER PRE-PULSE (μsec)	1.0	0.9	0.8	0.7	0.6	0.5	0.4	0.3	0.2	0.1	0	0	0	0	0	0	0	0	0

FIG. 15

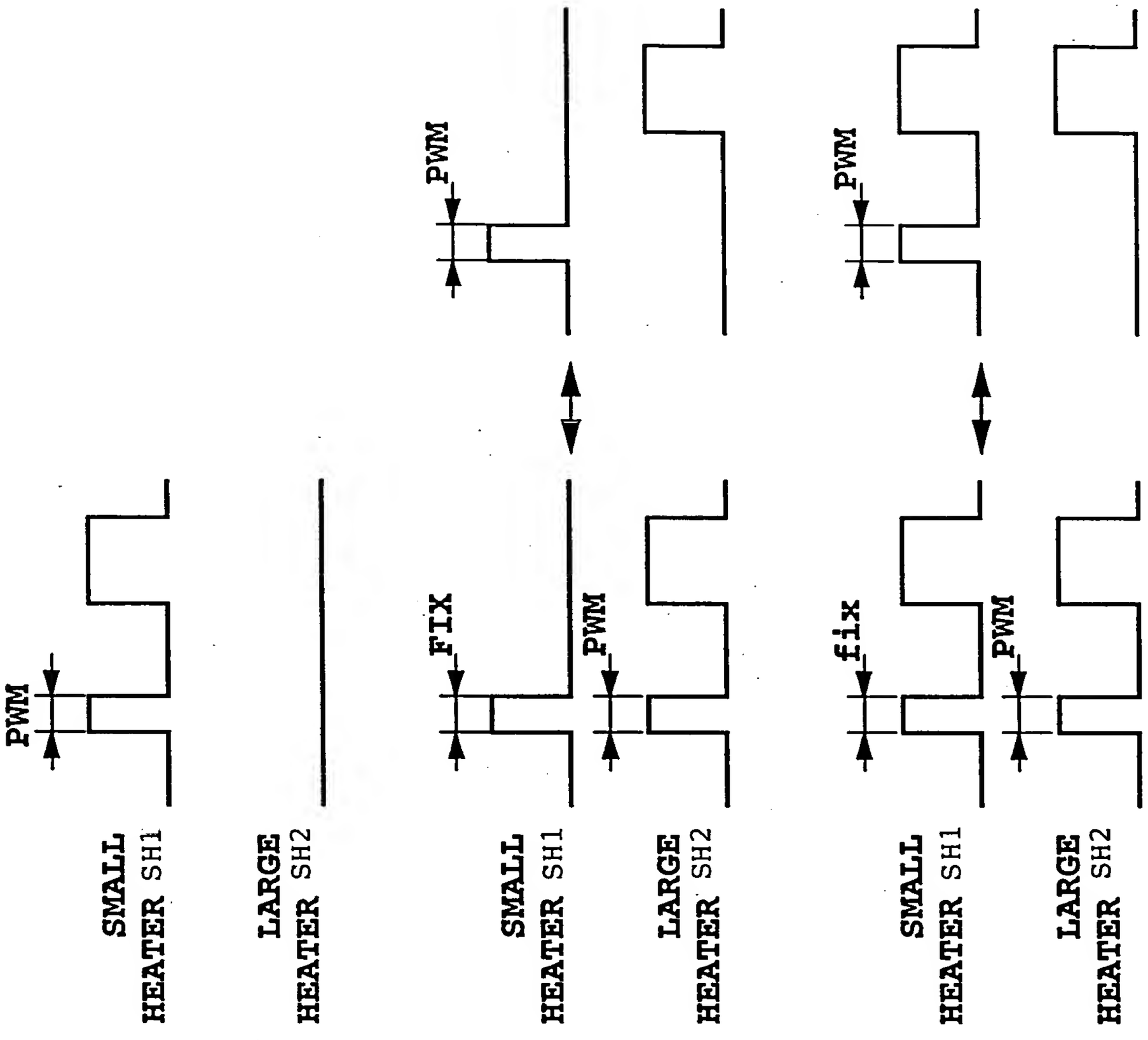

PWM
SMALL HEATER SH1
LARGE HEATER SH2
(FOR SMALL EJECTION AMOUNT MODE)
(a)
FIX
PWM
SMALL HEATER SH1
LARGE HEATER SH2
(FOR MEDIUM EJECTION AMOUNT MODE)
(b)
fix
PWM
SMALL HEATER SH1
LARGE HEATER SH2
(FOR LARGE EJECTION AMOUNT MODE)
(c)

FIG. 16

P_1 TABLE FOR SMALL EJECTION AMOUNT MODE
(FOR LOW TEMPERATURE)

(a)

HEAD TEMPERATURE T (℃)	~16	~18	~20	~22	~24	~26	~28	~30	~32	~34	~36	~38	~40	~42	~44	~46	~48	~50	50~
SMALL HEATER PRE-PULSE (μsec)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LARGE HEATER PRE-PULSE (μsec)	2.0	1.93	1.86	1.8	1.73	1.66	1.6	1.53	1.46	1.4	1.33	1.26	1.2	1.13	1.06	1.0	0.93	0.87	0.80

(15pl)

P_1 TABLE FOR MEDIUM EJECTION AMOUNT MODE
(FOR LOW TEMPERATURE)

(b)

HEAD TEMPERATURE T (℃)	~16	~18	~20	~22	~24	~26	~28	~30	~32	~34	~36	~38	~40	~42	~44	~46	~48	~50	50~
SMALL HEATER PRE-PULSE (μsec)	3.0	2.8	2.6	2.4	2.2	2.0	1.8	1.6	1.4	1.2	1.0	0.8	0.6	0.4	0.2	0	0	0	0
LARGE HEATER PRE-PULSE (μsec)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

(25pl)

FIG. 17

P_1 TABLE FOR LARGE EJECTION AMOUNT MODE
(FOR LOW TEMPERATURE)

(a)

HEAD TEMPERATURE (℃)	~16	~18	~20	~22	~24	~26	~28	~30	~32	~34	~36	~38	~40	~42	~44	~46	~48	~50	50~
SMALL HEATER PRE-PULSE (μsec)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LARGE HEATER PRE-PULSE (μsec)	2.0	1.9	1.8	1.7	1.6	1.5	1.4	1.3	1.2	1.1	1.0	0.9	0.8	0.7	0.6	0.5	0.4	0.3	0.2

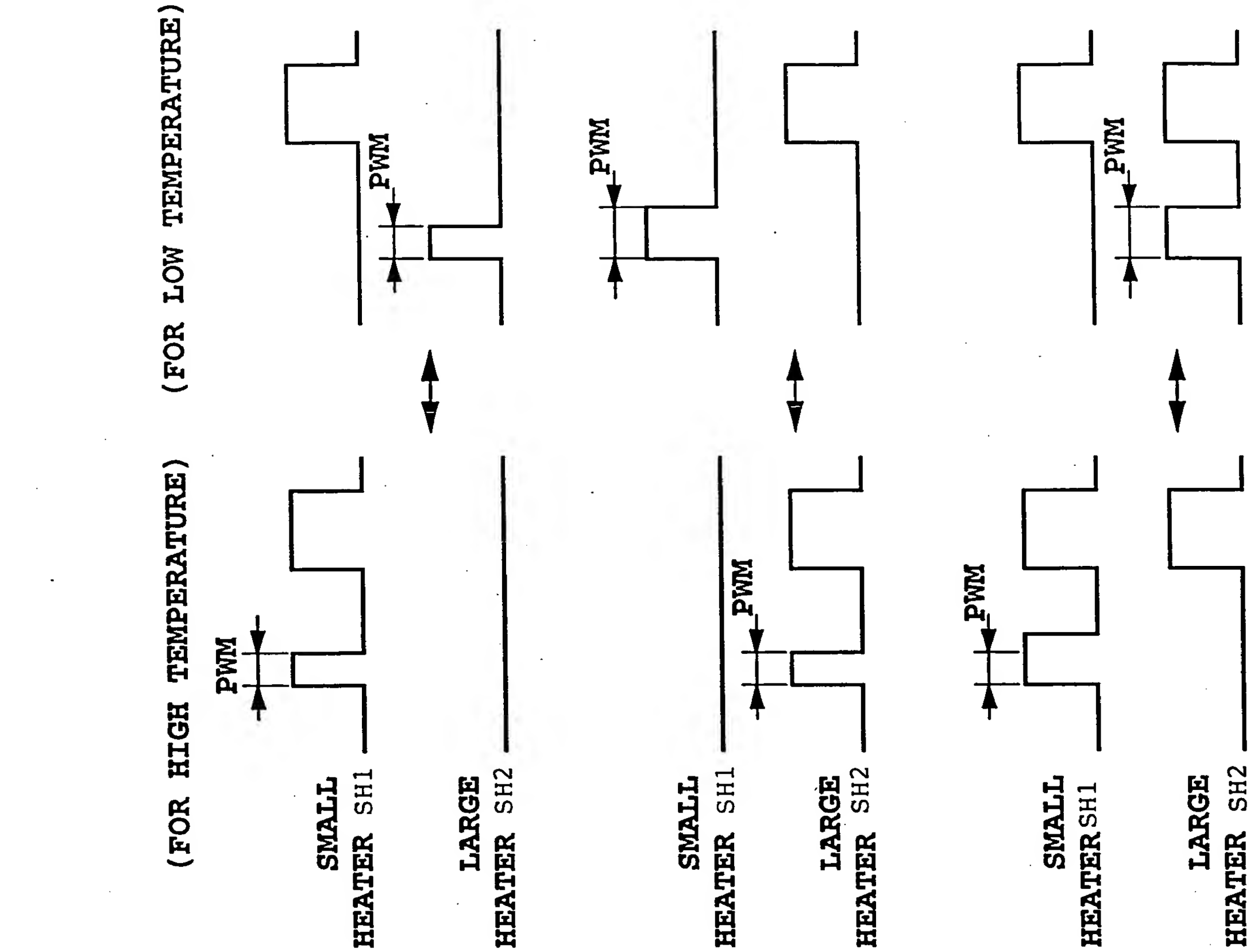
(40pl)

P_1 TABLE FOR LARGE EJECTION AMOUNT MODE
(FOR HIGH TEMPERATURE)

(b)

HEAD TEMPERATURE (℃)	~26	~28	~30	~32	~34	~36	~38	~40	~42	~44	~46	~48	~50	~52	~54	~56	~58	~60	60~
SMALL HEATER PRE-PULSE (μsec)	1.8	1.7	1.6	1.5	1.4	1.3	1.2	1.1	1.0	0.9	0.8	0.7	0.6	0.5	0.4	0..	30.2	0.1	0
LARGE HEATER PRE-PULSE (μsec)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

(40pl)



(a) (FOR SMALL EJECTION AMOUNT MODE)

(b) (FOR MEDIUM EJECTION AMOUNT MODE)

(c) (FOR LARGE EJECTION AMOUNT MODE)

(a)

OFF TIME P_2 TABLE FOR SMALL EJECTION AMOUNT MODE

HEAD TEMPERATURE T (℃)	~26	~28	~30	~32	~34	~36	~38	~40	~42	~44	~46	~48	~50	~52	~54	~56	~58	~60	60~
SMALL HEATER OFF TIME (μsec)	4.0	3.9	3.8	3.7	3.6	3.5	3.4	3.3	3.2	3.1	3.0	2.9	2.8	2.7	2.6	2.5	2.4	2.3	2.2
LARGE HEATER OFF TIME (μsec)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

(15pl)

(b)

OFF TIME P_2 TABLE FOR MEDIUM EJECTION AMOUNT MODE

HEAD TEMPERATURE T (℃)	~26	~28	~30	~32	~34	~36	~38	~40	~42	~44	~46	~48	~50	~52	~54	~56	~58	~60	60~
SMALL HEATER OFF TIME (μsec)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
LARGE HEATER OFF TIME (μsec)	4.0	3.8	3.6	3.4	3.2	3.0	2.8	2.6	2.4	2.2	2.0	1.8	1.6	1.4	1.2	1.0	0.8	0.6	0.4

(25pl)

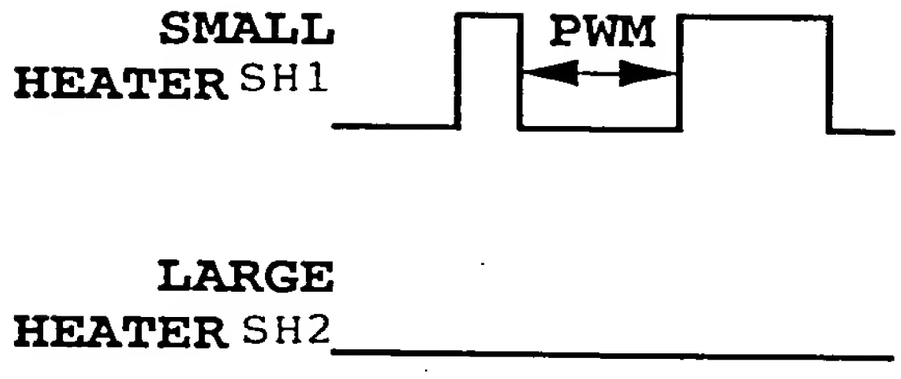
(c)

OFF TIME P_2 TABLE FOR LARGE EJECTION AMOUNT MODE

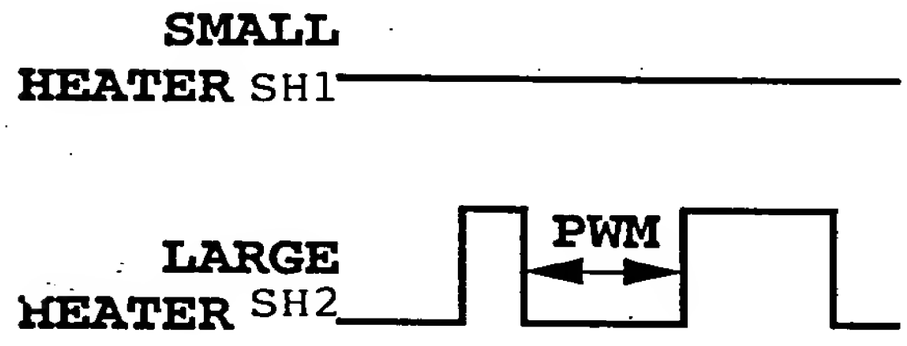
HEAD TEMPERATURE T (℃)	~26	~28	~30	~32	~34	~36	~38	~40	~42	~44	~46	~48	~50	~52	~54	~56	~58	~60	60~
SMALL HEATER OFF TIME (μsec)	4.0	3.9	3.8	3.7	3.6	3.5	3.4	3.3	3.2	3.1	3.0	2.9	2.8	2.7	2.6	2.5	2.4	2.3	2.2
LARGE HEATER OFF TIME (μsec)	4.0	3.9	3.8	3.7	3.6	3.5	3.4	3.3	3.2	3.1	3.0	2.9	2.8	2.7	2.6	2.5	2.4	2.3	2.2

(40pl)

(a) (FOR SMALL EJECTION AMOUNT MODE)



(b) (FOR MEDIUM EJECTION AMOUNT MODE)



(c) (FOR LARGE EJECTION AMOUNT MODE)

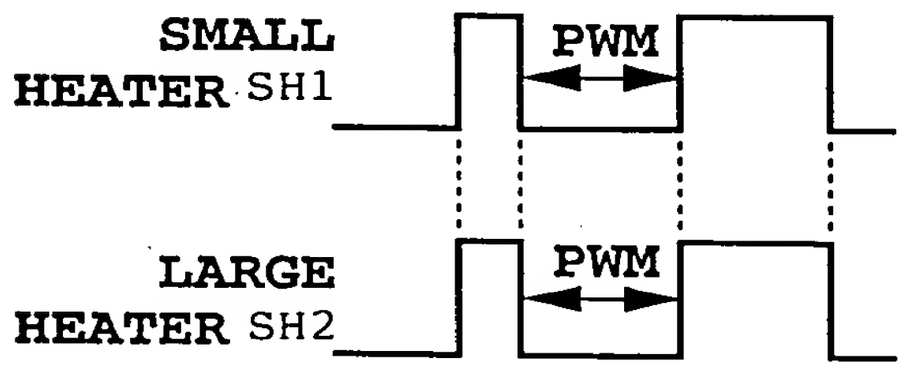


FIG. 21

OFF TIME P_2 TABLE FOR SMALL EJECTION AMOUNT MODE

(a)

HEAD TEMPERATURE T (℃)	~26	~28	~30	~32	~34	~36	~38	~40	~42	~44	~46	~48	~50	~52	~54	~56	~58	~60	60~
SMALL HEATER OFF TIME (μsec)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
LARGE HEATER OFF TIME (μsec)	4.0	3.8	3.6	3.4	3.2	3.0	2.8	2.6	2.4	2.2	2.0	1.8	1.6	1.4	1.2	1.0	0.8	0.6	0.4

(15pl)

OFF TIME P_2 TABLE FOR MEDIUM EJECTION AMOUNT MODE

(b)

HEAD TEMPERATURE T (℃)	~26	~28	~30	~32	~34	~36	~38	~40	~42	~44	~46	~48	~50	~52	~54	~56	~58	~60	60~
SMALL HEATER OFF TIME (μsec)	4.0	3.6	3.2	2.8	2.4	2.0	1.6	1.2	0.8	0.4	0								
LARGE HEATER OFF TIME (μsec)	-	-	-	-	-	-	-	-	-	-	-								

(25pl)

OFF TIME P_2 TABLE FOR LARGE EJECTION AMOUNT MODE

(c)

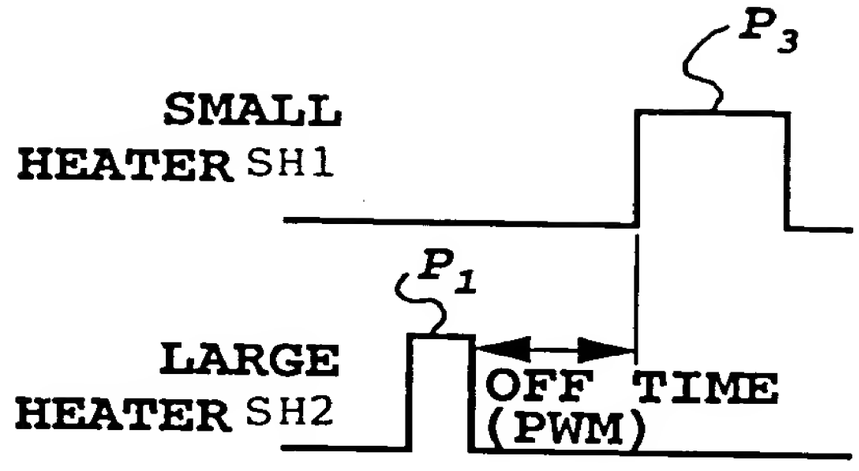
HEAD TEMPERATURE T (℃)	~26	~28	~30	~32	~34	~36	~38	~40	~42	~44	~46	~48	~50	~52	~54	~56	~58	~60	60~
SMALL HEATER OFF TIME (μsec)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
LARGE HEATER OFF TIME (μsec)	4.0	3.7	3.5	3.4	3.3	3.25	3.2	3.15	3.1	3.05	3.0	2.95	2.9	2.85	2.8	2.75	2.7	2.65	2.6

(40pl)

FIG. 22

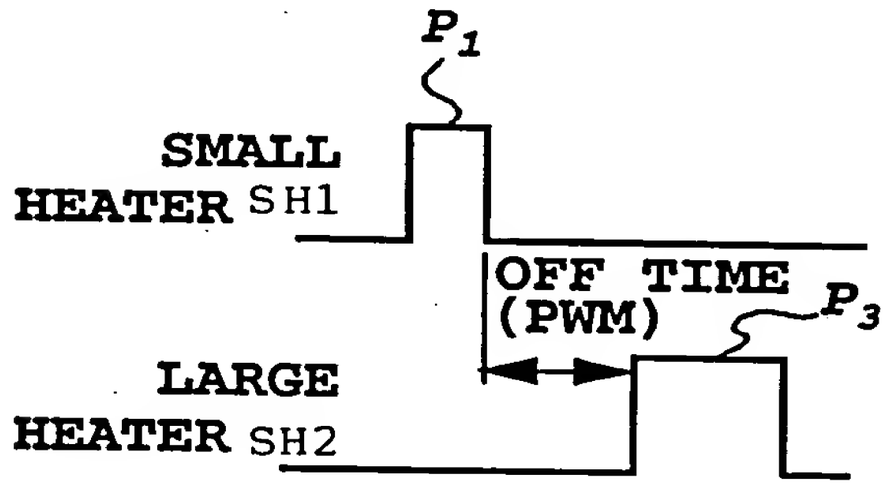
(a)

(FOR SMALL EJECTION AMOUNT MODE)



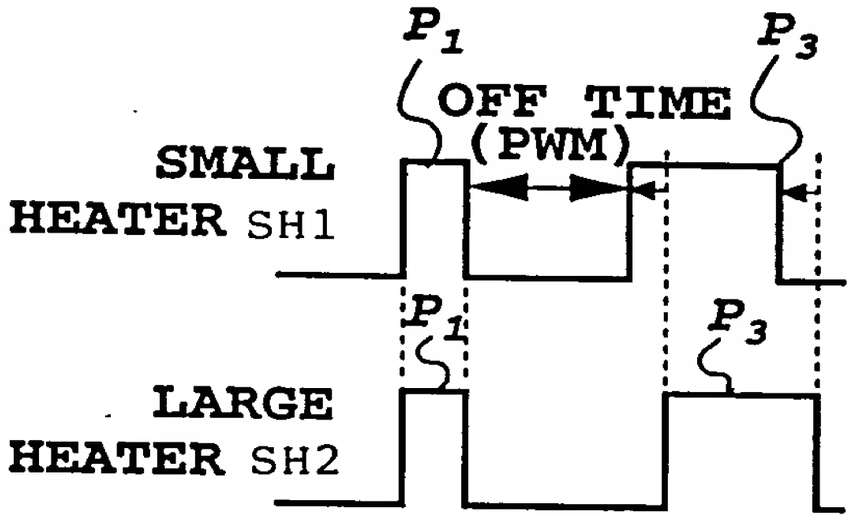
(b)

(FOR MEDIUM EJECTION AMOUNT MODE)



(c)

(FOR LARGE EJECTION AMOUNT MODE)



SH1: SMALL HEATER
SH2: LARGE HEATER

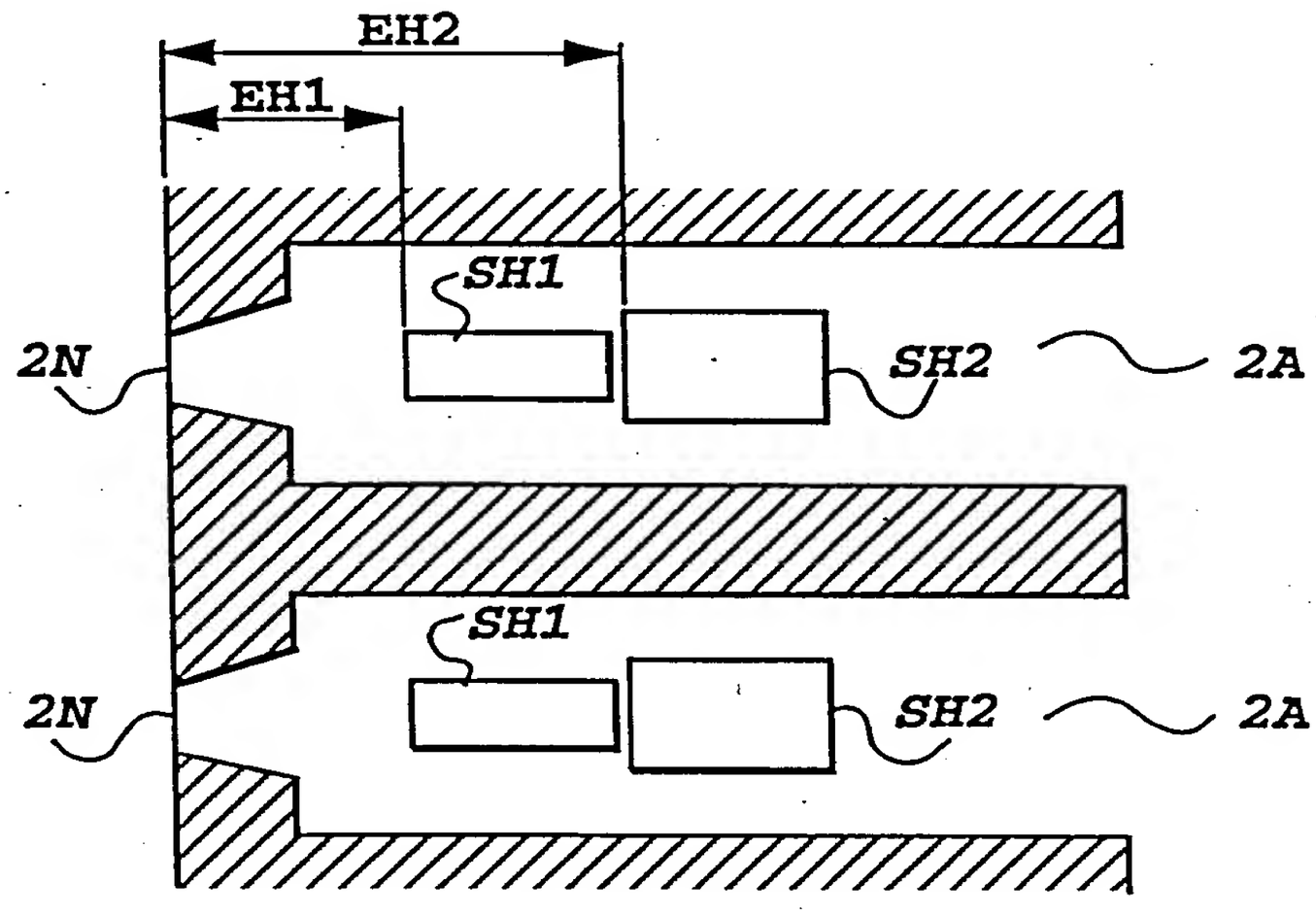


FIG. 23

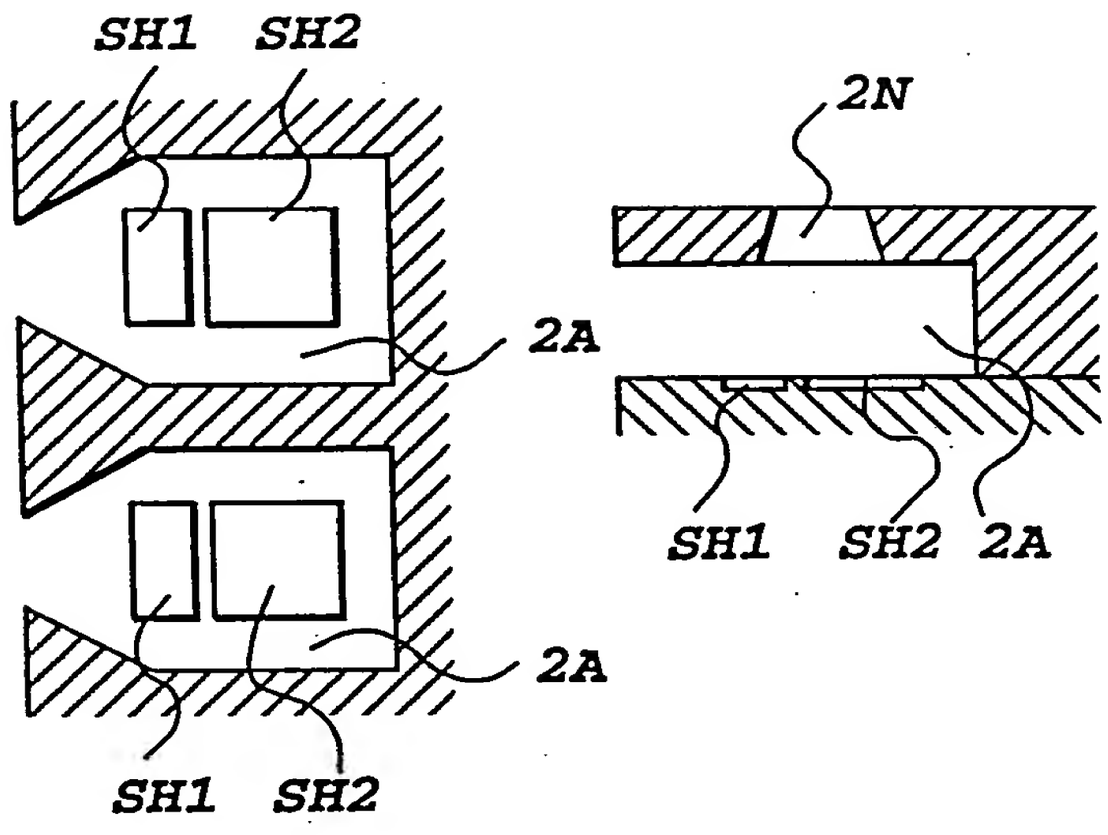


FIG. 24

[Document Name] Correction Data Ex Offico

[Document Corrected] Patent Application

<Information Acknowledged · Information Added>

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1. Date of Change August 30, 1990

[Reason for Change]New Registration

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[DOCUMENT NAME] ABSTRACT

[Abstract]

[Object]

In an ink-jet apparatus using an ink-jet head having a plurality of ejecting heaters for one ink ejection opening, ejection amount is made to be constant in each of ejection amount modes set by combination of the heaters irrespective of variations in head temperature.

[Construction]

With respect to each of small, middle and large ejection amount modes which are set by combinations of small and large heaters to be driven, pulses for driving the heaters are double pulses. Out of the pulses, the width P1 of a preceding pre-pulse is controlled depending upon a head temperature. Tables for the widths P1 of the preceding pre-pulses are provided for each of the ejection amount modes.

[Figure Selected]

Fig. 12

整理番号　２８３９１０５　　発送番号　３６６８８４
発送日　平成１２年１２月２０日　　１／　４

拒絶理由通知書

特許出願の番号	平成　６年　特許願　第３４０２６７号
起案日	平成１２年１２月１３日
特許庁審査官	桐畑　幸▲廣▼　　９６０６　２Ｐ００
特許出願人代理人	谷　義一　　（外　１名）様
適用条文	第２９条第２項、第３６条

この出願は、次の理由によって拒絶をすべきものである。これについて意見があれば、この通知書の発送の日から６０日以内に意見書を提出して下さい。

理　由

［理由１］
本願の下記の請求項に係る発明は、下記引用例に記載された発明に基づいて、当業者が容易に発明をすることができたものであるから、特許法第２９条第２項の規定により特許を受けることができない。

記

・請求項　１～６，８～２１，２３～３０
・引用例　１．特開平３－２３４６６６号公報
２．特開昭６２－２９０５６８号公報
３．特開平６－２３８９０２号公報
４．特開平２－３０１４４６号公報
５．特開昭６４－１４０４５号公報
６．特開昭５７－９５４７０号公報
７．特開昭６３－２８６３５６号公報
８．特開平２－２４３３５４号公報

続葉有

続　葉

９．特開平６－２２６９６３号公報
１０．特開平６－１９１１４２号公報

・備考

１．請求項１，２，４，６，１５～１７，１９，２１，３０に係る発明について

上記引用例１には、一つの吐出口に対して複数のヒータを配し、それらを適宜選択することによりドット径の変調を行うインクジェット記録装置であって、高速記録モード時には、使用する吐出口を２分の１に間引くとともに吐出インク量を大とするインクジェット記録装置が記載されている（第４頁左上欄第３行～右下欄下から２行目、第５頁右上欄第１行～第３行及び第４図参照）。

２．請求項３，１８に係る発明について

請求項１又は１６を引用する部分については上記のとおり。

また、上記引用例２には、各ヘッドの使用ノズルを設定することにより、ヘッド間の吐出位置を調整する技術が記載されており（第３頁左上欄下から４行目～左下欄最下行及び第３図参照）、引用例１に記載された発明に、引用例２に記載された上記技術を適用することは、当業者が容易に想到し得ることであり、その効果も当業者が予測し得る程度のものである。

３．請求項５，２０に係る発明について

請求項１又は１６を引用する部分については上記１．のとおり。

また、上記引用例３には、インクジェット記録において、大ピクセル３５のそばに小ピクセルを形成することにより、外側エッジに沿ったスカロッピングの影響を減少させる技術が記載されており（第６欄第２６行～第４０行及び【図１１】参照）、引用例１に記載された発明に、引用例３に記載された上記技術を適用することは、当業者が容易に想到し得ることであり、その効果も当業者が予測し得る程度のものである。

４．請求項８，２３に係る発明について

請求項５又は２０を引用する部分については上記３．のとおり。

また、上記引用例４，５等にもみられるように、インク滴の体積に応じてインク滴噴出手段へのパルス印加タイミングを変化させる技術は、本願の出願前に周知であって、当該周知の技術を引用例１に記載された発明に適用する点に、何ら格別の技術的困難性は認められない。

５．請求項９，２４に係る発明について

引用例３については上記３．のとおり。

また、上記引用例６には、インクジェットによる階調記録において、走査毎に駆動信号の供給時間を変化させる技術が記載されており（第２頁右下欄下から２行目～第３頁左上欄第２行及び表２参照）、引用例３に記載された発明に、引用

続　葉

例６に記載された上記技術を適用することは、当業者が容易に想到し得ることであり、その効果も当業者が予測し得る程度のものである。

更に、上記引用例７又は８には、１画素をディザマトリクスで構成し、かつ、マトリクス内に打ち込む微小ドット径を変化させる技術が記載されており、該ドット径をインク滴の大きさで変化させるようにすることは、当業者が容易に想到し得ることであり、その効果も当業者が予測し得る程度のものである。

６．請求項１０，２５に係る発明について

請求項９又は２４を引用する部分については上記５．のとおり。

また、上記引用例１等にもみられるように、複数のヒータの組合せによってインク滴の大きさを変える技術は、本願の出願前に周知であって、当該周知の技術を引用例３に記載された発明に適用する点に、何ら格別の技術的困難性は認められない。

７．請求項１１，２６に係る発明について

請求項９又は２４を引用する部分については上記５．のとおり。

また、上記引用例９には、被記録媒体の特性に応じてインク滴の量を可変とする技術が記載されており（特許請求の範囲参照）、引用例３に記載された発明に、引用例９に記載された上記技術を適用することは、当業者が容易に想到し得ることであり、その効果も当業者が予測し得る程度のものである。

更に、上記６．に記載したように、複数のヒータの組合せによってインク滴の大きさを変える技術は、本願の出願前に周知であって、当該周知の技術を引用例３に記載された発明に適用する点に、何ら格別の技術的困難性は認められない。

８．請求項１２，２７に係る発明について

引用例６については上記５．のとおり。

また、上記４．に記載したように、インク滴の体積に応じてインク滴噴出手段へのパルス印加タイミングを変化させる技術は、本願の出願前に周知であって、当該周知の技術を引用例６に記載された発明に適用する点に、何ら格別の技術的困難性は認められない。

９．請求項１３，２８に係る発明について

上記引用例１０には、キャリッジの往動作時のインク滴吐出体積を１２ｐｌ、復動作時のインク滴吐出体積を１８ｐｌとするインクジェット記録装置が記載されている（第６欄第２８行～第３６行参照）。

１０．請求項１４，２９に係る発明について

引用例１については上記１．のとおり。

また、上記４．に記載したように、インク滴の体積に応じてインク滴噴出手段へのパルス印加タイミングを変化させる技術は、本願の出願前に周知であって、

続　葉

当該周知の技術を引用例１に記載された発明に適用する点に、何ら格別の技術的困難性は認められない。

［理由２］

この出願は、明細書及び図面の記載が下記の点で、特許法第３６条第４項に規定する要件を満たしていない。

記

請求項７，２２における「送り量設定手段」が、発明の詳細な説明に、当業者が容易にその発明の実施をすることができる程度に記載されていない。

この拒絶理由通知の内容に関するお問い合わせ、または面接のご希望がございましたら下記までご連絡下さい。

審査第二部印刷・プリンター　桐畑　幸廣
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－－

先行技術文献調査結果の記録

・調査した分野　　ＩＰＣ第７版　Ｂ４１Ｊ　２／０５
　　Ｂ４１Ｊ　２／２０５

この先行技術文献調査結果の記録は、拒絶理由を構成するものではない。

(Translation)

Case No.: 2839105 Mailing Number: 366884
Mailing Date: December 20, 2000

OFFICIAL NOTICE OF REJECTION

Patent Application No. 340,267/1994

Date of Draft: December 13, 2000

Examiner, The Patent Office: Y. Kirihata 9606 2P00

Agent for Applicant: Yoshikazu Tani, Esq. (and one other)

Applied Provision(s): Section 29, Paragraph 2 and Section 36

The present application is rejected for the following reasons. The applicant may present an argument, if any, within 60 days from the mailing date of this Official Notice.

Reason 1

The invention(s) of the present application as claimed in claim(s) set forth below would have been obvious to one skilled in the art, to which the invention(s) pertain(s), prior to the filing date of the present application, on the basis of the publication(s) set forth below as distributed in Japan or foreign countries prior to the filing date of the present application. Thus, the present invention(s) is(are) unpatentable under the provision of Section 29, Paragraph 2 of the Patent Law.

Note

- Claims 1 to 6, 8 to 21, and 23 to 30

- References
1. Japanese Patent Application Laid-open No. Hei 3-234666
2. Japanese Patent Application Laid-open No. Sho 62-290568
3. Japanese Patent Application Laid-open No. Hei 6-238902
4. Japanese Patent Application Laid-open No. Hei 2-301446
5. Japanese Patent Application Laid-open No. Sho 64-14045
6. Japanese Patent Application Laid-open No. Sho 57-95470
7. Japanese Patent Application Laid-open No. Sho 63-286356
8. Japanese Patent Application Laid-open No. Hei 2-243354
9. Japanese Patent Application Laid-open No. Hei 6-226963
10. Japanese Patent Application Laid-open No. Hei 6-191142

- Remarks

1. The Invention According to Claims 1, 2, 4, 6, 15 to 17, 19, 21, and 30

Reference 1 discloses an ink jet printing apparatus, wherein a plurality of heaters are arranged for one ejection port, and these heaters are selected suitably, thereby performing dot-diameter modulation,

and wherein the ejection ports to be used are decimated to 1/2, and a large amount of ink is ejected during a high-speed printing mode (refer to page 4, upper left column, line 3 to the second line from the bottom of lower right column, page 5, upper right column; lines 1 to 3; and Fig. 4).

2. The Invention According to Claims 3 and 18

A portion which quotes claim 1 or claim 16 is as stated above.

Further, Reference 2 discloses the art of setting nozzles to be used in each head, thereby adjusting an ejection position between heads (refer to page 3, fourth line from the bottom of the upper left column to the bottom line of the lower left column and Fig. 3). It would have been obvious for one skilled in the art to apply the above art disclosed in Reference 2 to an invention disclosed in Reference 1. Advantageous result could have been expected by one skilled in the art.

3. The Invention According to Claims 5 and 20

A portion which quotes claim 1 or claim 16 is as stated in above section 1.

Further, Reference 3 discloses the art of forming a small pixel near a large pixel 35 in ink jet printing, thereby decreasing an effect of scalloping along an outside edge (refer to paragraph 6, lines 26 to 40 and Fig. 11). It would have been obvious for one skilled in the art to apply the above art disclosed in Reference 3 to the invention disclosed in Reference 1. Advantageous result could have been expected by one skilled in the art.

4. The Invention According to Claims 8 and 23

A portion which quotes claim 5 or claim 20 is as stated in above section 3.

Further, as disclosed in References 4 and 5, the art of changing a timing of applying a pulse to ink droplet ejecting means according to a volume of ink droplets is well known prior to the filing of the present application. It is obvious to apply the well-known art to the invention disclosed in Reference 1.

5. The Invention According to Claims 9 and 24

Refer to the above section 3 as to Reference 3.

In addition, Reference 6 discloses the art of changing a supply time of a drive signal every scanning in ink-jet gradation printing (refer to page 2, second line from the bottom of the lower right column to page 3, the upper left column, line 2 and Table 2). It would have been obvious for one skilled in the art to apply the above art disclosed in Reference 6 to an invention disclosed in Reference 3. Advantageous result could have been expected by one skilled in the art.

Further, Reference 7 or Reference 8 discloses the art of making one pixel composed of a dither matrix, and changing a fine dot diameter to be implanted in the matrix. It would have been obvious to change the dot diameter according to the size of an ink droplet. Advantageous result could have been expected by one skilled in the art.

6. The Invention According to Claims 10 and 25

A portion which quotes claim 9 or claim 24 is as stated in 5.

In addition, as disclosed in Reference 1, the art of changing the size of an ink droplet according to combination of a plurality of heaters is well known prior to the filing of the present application. There is no remarkable difficulty in applying the well-known art to the invention disclosed in Reference 3.

7. The Invention According to Claims 11 and 26

A portion which quotes claim 9 or claim 24 is as stated in 5.

In addition, Reference 9 discloses the art of making an amount of ink droplets variable according to the characteristics of a recording medium (refer to the claims). It would have been obvious for one skilled in the art to apply the above art disclosed in Reference 9 to the invention disclosed in Reference 3. Advantageous result could have been expected by one skilled in the art.

Further, as stated in above section 6, the art of changing the size of an ink droplet according to combination of a plurality of heaters is well known prior to filing of the present application. There is no remarkable technical difficulty in applying the well-known art to the invention disclosed in Reference 3.

8. The Invention According to Claims 12 and 27

Refer to the above section 5 as to Reference 6.

In addition, as stated in above section 4, the art of changing a timing of applying a pulse to ink droplet ejecting means according to a volume of ink droplets is well known prior

to filing of the present application. There is no remarkable technical difficulty in applying the well-known art to the invention disclosed in Reference 6.

9. The Invention According to Claims 13 and 28

Reference 10 discloses an ink jet printing apparatus wherein an ink droplet ejecting means during carriage forward movement in reciprocating movement is 12 pl, and an ink droplet ejection volume during backward movement is 18 pl (refer to column 6, lines 28 to 36).

10. The Invention According to Claims 14 and 29

Refer to the above section 1 for Reference 1.

As stated in above section 4, the art of changing a timing of applying a pulse to ink droplet ejecting means according to a volume of ink droplets is well known prior to filing of the present application. There is no remarkable technical difficulty in applying the well-known art to the invention disclosed in Reference 1.

Reason 2

The present application fails to conform to the requirement prescribed under Section 36, Paragraph 4 of the Japanese Patent Law in the points stated below.

Note

The Detailed Description of the Invention section fails to describe "feed quantity setting means" recited in claims 7 and 22 to an extent such that the invention can be readily carried out by one skilled in the art.

Record of Search Result of Prior Art Literature

- Searched Field

IPC seventh edition	B41J	2/05
	B41J	2/205

This record of search result of prior art literature does not constitute reason for rejection.

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Group Art unit: 2853

Examiner: S. Johnson, Jr.

Applicants	:	**Noribumi KOITABASHI et al.**)	
Application No.:		**08/579,241**)	TRANSLATION OF
		)	PRIORITY
Filed	:	**December 28, 1995**)	DOCUMENTS
		)	DECLARATION
		)	IN SUPPORT
		)	THEREOF
For	:	**INK-JET APPARATUS EMPLOYING**)	
		INK-JET HEAD HAVING A)	
		PLURALITY OF INK EJECTION)	
		HEATERS CORRESPONDING TO)	
		EACH INK EJECTION OPENING)	

Assistant Commissioner for Patents
Washington, D.C. 20231

Sir:

I, Atsuko SEKIGUCHI, of Tani & Abe Patent Office, No. 6-20, Akasaka 2-chome, Minato-ku, Tokyo 107-0052, Japan, declare that:

1. I know well both the Japanese and English languages.

2. I translated Japanese Patent Application No. 340267/1994 of December 29, 1994 from the Japanese language to the English language, a copy of the translation being attached hereto.

3. The attached English translation of the Japanese application identified in paragraph 2 above is a true and correct translation to the best of my knowledge and belief.

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code, and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

Signed this July 17, 2000

Atsuko Sekiguchi

Atsuko SEKIGUCHI

PATENT OFFICE
JAPANESE GOVERNMENT

This is to certify that the annexed is a true copy of the following application as filed with this Office.

Date of Application: December 29, 1994

Application Number: Japanese Patent Application No. 340267/1994

Applicant(s): CANON KABUSHIKI KAISHA

January 26, 1996

Commissioner,
Patent Office Yuji KIYOKAWA

Certificate No. 3085357/1995

(Translation)
340267/1994

Applicant's Case Number: 2839105 (1/2)

(Document's Name) Patent Application

(Case Number) 2839105

(Filing Date) December 29, 1994

To: Commissioner, the Patent Office

(International Patent Classification) B41J 2/01

(Title of the Invention)

AN INK-JET APPARATUS

(Number of claims) 15

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340267/1994

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(Method of Payment)	Pre-payment
(Account Number of Payment)	013424
(Amount)	¥21,000.-

(List of the filing documents)

Specification	1 copy
Formal Drawings	1 copy
Abstract	1 copy
General Authorization Number	9004548

(Necessity of Proof) Yes

[DOCUMENT NAME] SPECIFICATION

[TITLE OF THE INVENTION]

An Ink-Jet Apparatus

[SCOPE OF CLAIM FOR A PATENT]

[Claim 1]

An ink-jet apparatus for ejecting ink from an ink-jet head toward a medium by the use of the ink-jet head having a plurality of heaters for one ink ejection opening, the ink-jet apparatus comprising:

setting means for setting the presence or absence of heater driving irrespective of ejection data for each of the plurality of heaters; and

ejection data setting means for establishing the correspondence between ejection data and the ejection opening for ejecting ink based on the ejection data depending upon combination of the presence or absence of heater driving set by the setting means.

[Claim 2]

An ink-jet apparatus as claimed in claim 1 wherein a printing density is set based on the setting by the setting means and the correspondence established by the ejection data setting means.

[Claim 3]

An ink-jet apparatus as claimed in claim 1, wherein an ejecting position between the plurality of ink-jet heads is adjusted based on the setting by the

setting means and the correspondence established by the ejection data setting means.

[Claim 4]

An ink-jet apparatus as claimed in claim 1, wherein an ink amount to be ejected for one pixel is set based on the setting by the setting means and the correspondence established by the ejection data setting means.

[Claim 5]

An ink-jet apparatus as claimed in claim 1, further comprising data generating means for generating interpolating ejection data based on the ejection data, wherein the ejection data setting means establishes correspondence of the interpolating ejection data to an ejection opening other than the ejection opening to which the correspondence has been established.

[Claim 6]

An ink-jet apparatus as claimed in claim 3, wherein the ejection amount of each of the ejection openings, to which the correspondence has been established, is set by the combination of the driven heaters so as to determine the ink amount to be ejected for one pixel.

[Claim 7]

An ink-jet apparatus as claimed in claim 5, further comprising feeding amount setting means for

setting a relative shifting amount between the ink-jet head and the medium depending upon the combination of the presence or absence of the heater driving set by the setting means, wherein printing is performed within a predetermined range on the medium by scanning of the ink-jet head by the number of times determined by the relative shifting amount set by the feeding amount setting means.

[Claim 8]

An ink-jet apparatus as claimed in claim 5 or claim 6, wherein an ejection timing is varied depending upon the ejection amount set for the ejection opening, to which the correspondence has been established.

[Claim 9]

An ink-jet apparatus for performing printing by using an ink-jet head having ejection openings capable of ejecting ink droplets of a plurality of sizes in different manners in only one scanning cycle or per scanning, the ink-jet apparatus comprising:

means for driving the ink-jet head with a shift relative to the medium in such a manner that the ink droplets of the plurality of sizes are compensated with each other.

[Claim 10]

An ink-jet apparatus as claimed in claim 9, wherein the ink droplets of the plurality of sizes are

formed by the combination of the plurality of heaters in the ink-jet head.

[Claim 11]

An ink-jet apparatus as claimed in claim 9, wherein the combination of the plurality of heaters is varied depending upon a type of medium to be used.

[Claim 12]

An ink-jet apparatus for performing printing by using an ink-jet head having ejection openings capable of ejecting ink droplets of a plurality of sizes in different manners in only one scanning cycle or per scanning, the ink-jet apparatus characterized in that an ejection timing of the ink droplet is shifted depending upon the size of the ink droplet.

[Claim 13]

An ink-jet apparatus having an ink-jet head capable of ejecting ink droplets of mutually different two sizes and being capable of printing in forward and reverse directions, the ink-jet apparatus comprising:

switching means for switching a first mode in which large ink droplets are ejected in one of the forward and reverse printing directions and a second mode in which small ink droplets are ejected in the other direction.

[Claim 14]

An ink-jet apparatus having an ink-jet head capable of ejecting ink droplets of a plurality of

sizes from one and the same ejection opening, the ink-jet apparatus comprising:

means for varying an ejection timing of the ink droplet depending upon the size of the ink droplet or the combination of heaters to be driven.

[Claim 15]

An ink-jet apparatus for performing printing at a density of 1/N of an alignment density in an ejection opening group of 1/N (N ≥ 2) of an ejection opening array by using an ink-jet head having a plurality of ejection openings aligned, the ink-jet apparatus characterized in that there is provided an ejection amount mode depending upon the printing density.

[DETAILED DESCRIPTION OF THE INVENTION]

[0001]

[Field of Industrial Utilization]

The present invention relates to an ink-jet apparatus. More specifically, the invention relates to an ink-jet apparatus using an ink-jet head having a plurality of ejecting heaters on an ink path corresponding to each of ink ejection openings.

[0002]

[Prior Art]

An ink-jet apparatus has been mainly known as a printing apparatus in printers, copy machines and the like. Among various ink-jet apparatus, there has become recently widespread an ink-jet printing

apparatus of the type in which thermal energy is used as energy for ink ejection, for ejecting ink with bubbles generated by the thermal energy. In addition, as other applications of this type of ink-jet printing apparatus has become known in recent years an ink-jet textile printing apparatus for printing a given pattern, a picture, a synthesized image or the like on cloth.

[0003]

An ink-jet head for use in such an ink-jet printing apparatus as described above has an electrothermal transducer element (hereinafter also referred to as "a heater") as a source for generating thermal energy. In most cases, the ink-jet head is provided with one heater corresponding to one ejection opening. In contrast, there has been known an ink-jet head using a plurality of heaters in each of ink ejection openings for the reasons discussed below.

[0004]

First, it has been known to alternately or selectively drive a plurality of heaters for the purpose of extension of the life of the ink-jet head. Second, a plurality of heaters are used for widening the range of variations in ink ejection amount, wherein the ink ejection amount is varied by selecting heaters to be driven or the number of heaters to be driven.

[0005]

In the latter case, in a more specific structure, a plurality of heaters are arranged along an ink ejecting direction on an ink path communicating with the ejection opening in the ink-jet head, so that a distance between the ejection opening and the heaters to be driven is varied by selecting the heaters to be driven (namely, the heaters to be made to generate heat) or the number of heaters to be driven, thus varying the ejection amount of the ink.

[0006]

Another structure of the ink-jet head has been known in which a plurality of heaters different in surface area are arranged on an ink path, to make an ink ejection amount variable by varying the heaters to be driven or the number of heaters to be driven.

[0007]

[Problems to be Solved by the Invention]

However, regarding to a plurality of heaters, the above-mentioned prior art only shows the structure for making the ink ejection amount variable by selectively driving a plurality of heaters. Therefore, an image of good quality cannot be printed even if the prior art is applied to multiple printing as it is.

[0008]

For example, when the ejection amount is varied in a relatively wide range by using a plurality of

heaters, the ejection speed for each ejection amount is significantly varied in association therewith. In this case, in a so-called serial type printing apparatus, in which printing is performed by scanning of the ink-jet head, a depositing position of ejected ink may be shifted by variations in ejecting speed. As a result, there arises a problem of degradation of an image quality.

[0009]

The present invention has been accomplished in an attempt to solve the above-described problem. Therefore, an object of the present invention is to provide an ink-jet printing apparatus which can constantly print a good image even when tone printing or the like is performed by varying the ejection amount.

[0010]

The present inventor implemented the present invention in consideration that ink can be ejected in different amount from each of a plurality of ink ejection openings. Consequently, another object of the present invention is to provide an ink-jet apparatus and ink-jet printing method, in which printing can be performed in various modes by combinations of the ejection openings and ejection amounts to be ejected from the ejection openings.

[0011]

[Means for Solving the Problems]

According to the present invention, an ink-jet apparatus for ejecting ink from an ink-jet head toward a medium by the use of the ink-jet head having a plurality of heaters for one ink ejection opening, comprises: setting means for setting the presence or absence of heater driving irrespective of ejection data for each of the plurality of heaters; and ejection data setting means for establishing the correspondence between ejection data and the ejection opening for ejecting ink based on the ejection data depending upon combination of the presence or absence of heater driving set by the setting means.

[0012]

Furthermore, an ink-jet apparatus for performing printing by using an ink-jet head having ejection openings capable of ejecting ink droplets of a plurality of sizes in different manners in only one scanning cycle or per scanning, comprises means for driving the ink-jet head with a shift relative to the medium in such a manner that the ink droplets of the plurality of sizes are compensated with each other.

[0013]

Moreover, in an ink-jet apparatus for performing printing by using an ink-jet head having ejection openings capable of ejecting ink droplets of a

plurality of sizes in different manners in only one scanning cycle or per scanning, an ejection timing of the ink droplet is shifted depending upon the size of the ink droplet.

[0014]

Additionally, an ink-jet apparatus having an ink-jet head capable of ejecting ink droplets of mutually different two sizes and being capable of printing in forward and reverse directions, comprises switching means for switching a first mode in which large ink droplets are ejected in one of the forward and reverse printing directions and a second mode in which small ink droplets are ejected in the other direction.

[0015]

Furthermore, an ink-jet apparatus having an ink-jet head capable of ejecting ink droplets of a plurality of sizes from one and the same ejection opening, comprises means for varying an ejection timing of the ink droplet depending upon the size of the ink droplet or the combination of heaters to be driven.

[0016]

Moreover, in an ink-jet apparatus for performing printing at a density of 1/N of an alignment density in an ejection opening group of 1/N ($N \geq 2$) of an ejection opening array by using an ink-jet head having a plurality of ejection openings aligned, there is

provided an ejection amount mode depending upon the printing density.

[0017]

[Function]

With the above-described configuration, the ink amount to be ejected from each of the ejection openings can be variably set, and further, the printing mode according to the setting can be set.

[0018]

[Preferred Embodiments]

Preferred embodiments according to the present invention will be discussed hereinafter in detail with reference to the accompanying drawings.

[0019]

Fig. 1 is a perspective view showing a printer as an ink-jet printing apparatus according to the present invention.

[0020]

In Fig. 1, reference numeral 101 denotes a printer, reference numeral 102 denotes an operation panel provided at the upper front portion of a housing of the printer 101, reference numeral 103 denotes a sheet feeding cassette to be inserted into an opening at the front face of the housing, reference numeral 104 denotes a sheet (recording medium) to be fed from the sheet feeding cassette 103, and reference numeral 105 denotes a discharged sheet tray for holding sheets

discharged via a sheet feeding path inside the printer 101. Reference numeral 106 denotes a main body cover in an L-shaped cross section. The main body cover 106 is designed for covering an opening 107 formed at the right front portion of the housing, and is pivotally mounted at the inner end of the opening 107 by means of a hinge 108. In addition, within the housing, a carriage 110 supported by a guide or the like (not shown) is arranged. The carriage 110 is provided in such a manner as to movably reciprocate in a width direction of the sheet to be fed on the sheet feeding path (hereinafter also referred to as "a primary scanning direction").

[0021]

The carriage 110 in the present embodiment generally comprises a stage 110a to be held horizontally by the guide or the like, an opening (not shown) for accommodating ink-jet heads at a rear portion on the stage 110a, a cartridge garage 110b for receiving ink-jet heads 3Y, 3M, 3C and 3Bk which are detachably loaded on the stage 110a in front of the opening, and a cartridge holder 110c opened and closed relative to the garage 110b so as to prevent any detachment of a cartridge received within the garage 110b.

[0022]

The stage 110a is slidably supported at the rear end thereof by means of a guide, and further, slidably engages with a not-shown guide plate at the lower portion of the front end thereof. The guide plate may serve as a sheet holding member for preventing the sheet fed via the sheet feeding path from floating, or may have a function of lifting up the stage relative to the guide in a cantilever fashion according to the thickness of the sheet.

[0023]

In the opening of the stage 110a is loaded the ink-jet head (not shown) with ink ejecting openings directed downward.

[0024]

The cartridge garage 110b is provided with a through opening extending in a lengthwise direction, for simultaneously receiving the four ink-cartridges 3Y, 3M, 3C and 3Bk. On the both sides of the outer surfaces of the cartridge garage 110b are formed engaged recesses to be engaged with engaging claws of the cartridge holder 110c.

[0025]

At the front end of the stage 110a, the cartridge holder 10c is pivotally mounted via a hinge 116. The dimension from the front end of the garage 110b to the hinge 116 is determined in consideration of a

projecting dimension from the cartridges 3Y, 3M, 3C and 3Bk from the front end of the garage 110b when the cartridges 3Y, 3M, 3C and 3Bk are received inside the garage 110b. The cartridge holder 110c is formed into a substantially rectangular plate. On the cartridge holder 110c, a pair of engaging claws 110e project in a direction perpendicular to the plate surface on both sides of the upper portion away from the lower portion fixed via the hinge 116, and engage with engaged recesses 110d formed at the garage 110b when the holder 110c is closed. An insertion hole 120, to which the respective handles of the cartridges 3Y, 3M, 3C and 3Bk are inserted, is formed in the plate of the holder 110c. The insertion hole 120 is formed into a corresponding shape at a corresponding position in a corresponding size to the handles.

[0026]

Fig. 2 is a block diagram illustrating an example of the arrangement of a control system in the ink-jet printing apparatus.

[0027]

Here, reference numeral 200 denotes a controller constituting a main control unit, which includes a CPU 201 in a form of, for example, a microcomputer for executing various modes, described later, a ROM 203 storing therein fixed data such as programs, tables, voltage values of a heat pulse and pulse widths, and a

RAM 205 provided with a region for developing image data and a region for working. Reference numeral 210 denotes a host system (or a reader unit for reading an image) serving as a supply source of the image data. The image data, other commands, status signals and the like are transmitted to or received from the controller via an interface (I/F) 212.

[0028]

The operation panel 102 is provided with a switch group which receives commands input by an operator and includes a mode selector switch 220 for selecting various modes, a power source switch 222, a print switch 224 for designating starting of printing, an ejection recovering switch 226 for designating initiation of ejection recovering processes, and the like, as described later. Reference numeral 230 denotes a sensor group which detects the condition of the apparatus and includes a sensor 232 for detecting positions of the carriage 110 (see Fig. 1) such as a home position and a start position, and a sensor 234 to be used for detecting a pump position including a leaf switch.

[0029]

Reference numeral 240 denotes a head driver for driving an electrothermal transducer element of the ink-jet head in accordance with printing data and the like. A part of the head driver also may be used for

driving temperature heaters 30A and 30B. Furthermore, temperature detection values are input to the controller 200 from temperature sensors 20A and 20B. Reference numeral 250 denotes a primary scanning motor for shifting the carriage 110 in a primary scanning direction, and reference numeral 252 denotes a driver for the motor 250. Reference numeral 260 denotes an auxiliary scanning motor which is used for feeding the sheet 104 as the recording medium (see Fig. 1).

[0030]

The above-mentioned ink-jet printing apparatus has the ink-jet head cartridges 2C, 2M, 2Y and 2Bk for inks of four colors, i.e., cyan, magenta, yellow and black, respectively.

[0031]

Fig. 3 is a cross-sectional view showing an ink tank cartridge 3 and an ink-jet head 2 to be used in the above-mentioned ink-jet printing apparatus in a connected state.

[0032]

The ink tank cartridge 3 used in the present embodiment includes two chambers of a vacuum generating member containing chamber 53 filled with ink absorbers 52, and an empty ink containing chamber 56. In the initial condition, ink is filled in both of these chambers. In association with ink ejection

and the like in the ink-jet head 2, the ink in the ink containing chamber 56 is first consumed.

[0033]

The ink-jet head 2 has heaters (not shown in Fig. 3) for generating thermal energy to be used for ejection on a plurality of ink paths 2A corresponding to the ink ejection openings, for ejecting the ink supplied from the ink tank cartridge 3 via a connection pipe 4.

[0034]

(First Embodiment)

Fig. 4 is a cross-sectional view schematically showing the structure of the ink-jet head 2 in the first embodiment according to the present invention.

[0035]

As shown in Fig. 4, two heaters SH1 and SH2 are arranged on each of the ink paths 2A in the longitudinal direction. The two heaters are different in surface area from each other, and electrodes are wired (not shown) such that the heaters can be driven independently of each other or simultaneously. It should be noted that the heaters SH1 and SH2 are the same in length in the longitudinal direction of the ink path 2A but are different in width, and therefore, they are different in surface area from each other. At the tip end of the ink path 2A is opened an ejection opening 2N.

[0036]

The structures, which are provided in the predetermined number per ink path and each of which consists of the heaters, the ejection opening and the ink path, are arranged in the ink-jet head 2 in the density of 360 DPI. In the present embodiment, the area of the ejection opening and the area of the heater are the same in each ink path.

[0037]

In the present embodiment, basically, the ink ejection amount can be set at three steps (hereinafter referred to as "basic ejection amount modes") depending upon the combination of the heaters to be driven in each of the ejection openings in the case where two heaters are used. Hereinafter, description will be given of the basic ejection amount modes in the present embodiment.

[0038]

Basic ejection amount modes in the present embodiment will be explained before explanation of various printing modes set in the present embodiment.

[0039]

Basically, three ejection amount modes, i.e., small, medium and large, can be achieved by switching the heater to be driven. In the small ejection amount mode, only the heater SH1 is driven to eject 15 pl in volume of liquid droplets; in the medium ejection

amount mode, only the heater SH2 is driven to eject 25 pl in volume of ink droplets; and in the large ejection amount mode, both of the heaters SH1 and SH2 are driven simultaneously to eject 40 pl (= 15 + 25 pl) of liquid droplets.

[0040]

<Printing Mode>

(360 DPI mode: normal printing mode)

This mode is to perform printing in 360 DPI in the large ejection amount mode by setting to drive heaters for only odd-numbered or even-numbered ejection openings in the ejection array in a density of 720 DPI in the ink-jet head 2.

[0041]

In this mode, it becomes possible to extend the life of each of the heaters by switching setting of the odd-numbered ejection openings and the even-numbered ejecting openings alternatively, for example, per page of printing. It should be noted that switching of the ejection opening groups is prohibited within the printing range of one unit such as one page.

[0042]

(Vertical Registration Adjusting Mode)

This mode is a modification of the 360 DPI mode. Namely, as discussed in reference to Fig. 1, in the apparatus where ink-jet heads of respective colors are arranged in a primary scanning direction, like a

printer in the present embodiment, it may happen that the installation positions of respective ink-jet heads are shifted due to tolerance in a sub-scanning direction. In this case, with respect to the odd-numbered ejection opening group and the even-numbered ejection opening group set in the ink-jet head as a reference, switching of the odd-numbered and even-numbered ejection opening groups is set in the ink-jet head with a shift, so that the positional shift of the ejection opening can be adjusted in the width of 720 DPI.

[0043]

(240 DPI Mode)

This mode is to perform printing in the medium ejection amount mode by using one of three ejection opening groups divided by the remainder of three. Switching of the ejection opening group and the vertical registration adjusting mode as a modified mode are similar to the above-described 360 DPI mode.

[0044]

As a matter of course, in the 360 DPI mode or 240 DPI mode, the dot (ejection) data to be finally supplied to the head driver 240 (see Fig. 2) is dot data for 360 DPI mode or 240 DPI mode. Also, the ejection timing is set to form the dot at the density corresponding to each of the DPI modes in the primary scanning direction.

[0045]

(High Density Mode)

This mode is to make adjacent two ejection openings correspond to the data corresponding to one dot of data of 360 DPI. Specifically, in the ejection opening array, the heaters for the first and second ejection openings are adapted to be driven to form a dot corresponding to one dot data with the ink ejected through each of the ejection openings. Similarly, the third and fourth ejection openings, ..., (2m-1)th and (2m)th (m is a natural number) ejection openings respectively eject ink to form a dot corresponding to each of dot data (see Fig. 5).

[0046]

Also, even in the 240 DPI mode, adjacent openings may be corresponded to one dot data. In this case, specifically, the first and second ejection openings, the fourth and fifth ejection openings, ..., the (3m-2)th and (3m-1)th ejection openings are corresponded to each dot corresponding to one dot data so as to form the dot of ink. Alternatively, the second and third ejection openings, the fifth and sixth ejection openings, ..., the (3m-1)th and (3m)th ejection openings are corresponded to each dot corresponding to one dot data so as to form the dot of ink. Otherwise, the first, second and third ejection openings, the fourth, fifth and sixth ejection openings, ..., the

(3m-1)th, (3m-2)th and (3m)th ejection openings may be corresponded to each dot corresponding to one dot data so as to form the dot of ink.

[0047]

The high density mode is desired to be selected depending upon the kind of recording medium. In particular, when the recording medium having a low bleeding rate of the ink is used, this mode is effective since blurring may be generated in a solid portion or a low density may be caused in a normal printing mode. Furthermore, this mode is effective also in a recording medium such as cloth in which the density becomes low due to excessively high penetration of an ink dye.

[0048]

(720 DPI Mode)

This mode is basically to perform printing of 720 DPI × 720 DPI by using all of the ejection openings in the small ejection amount mode.

[0049]

Also, in this mode, an effect similar to that in the high density mode can be attained by switching the ejection amount mode to the large or medium ejection amount mode for a certain recording medium.

[0050]

It should be noted that since the dot density is high in this mode, when the ink is ejected through

adjacent ejection openings in the large ejection amount mode, the ink droplet deposited on the recording medium can be adjoined to cause so-called beading. Therefore, it is desirable to perform distributed driving such as thinning printing.

[0051]

(Smoothing Mode)

This mode is to perform smoothing by using the ejection openings other than the ejection openings used for printing in 360 DPI or 240 DPI, with respect to the dot data of 360 DPI and 240 DPI. It should be noted that, in performing smoothing, it is desirable to allow the dots to be formed in the smoothing mode by reducing the ejection amount to be ejected through the additional ejection openings than that set for the ejection openings to perform printing.

[0052]

Fig. 6 is a flowchart illustrating a process for setting smoothing data, and Fig. 7 schematically illustrates a dot pattern as the calculation result of interpolating dot data in the smoothing process.

[0053]

When the smoothing mode is set by the operation of the user or command from the host system, the process illustrated in Fig. 6 is initiated. In step S61, dot data for one scanning line is developed, and then, the interpolating dot data is calculated in

accordance with predetermined algorithm in step S62.

[0054]

One example of the above algorithm is illustrated in Fig. 7. Fig. 7 illustrates a smoothing process in 360 DPI mode. Here, a hatched circle indicates the interpolating dot data, and a white circle represents the original dot data. As shown in Fig. 7, the interpolating dot is formed by using the ejection openings located between two adjacent ejection openings to be used for 360 DPI mode printing, and by printing in the small ejection amount mode. In this case, the interpolating dot data is generated by the following algorithm. With respect to one dot data as original dot data (white circle) in question, generation of the interpolating dot data is determined depending upon the presence or absence of the original dot data in the vertical and lateral directions and diagonal directions. For example, when another dot data is present in the diagonally upper position relative to the dot data in question, the interpolating dot data is generated at the intermediate points (points a and b shown in Fig. 7) at the upward position and the obliquely upward position relative to the dot data in question.

[0055]

When generation of the interpolating dot data is completed as set forth above, in step S63 in Fig. 6,

these interpolating dot data is stored in the predetermined memory as drive data of the corresponding ejection openings. The sequence from step S61 to step S63 is executed with respect to the ejection data for, for example, one page (step S64), this processing is terminated.

[0056]

(Multi-Value Printing Mode)

This mode is a mode in which large, medium and small ejection amount modes are switched depending upon density data of each pixel (hereinafter also referred to as "multi-value data") based on the above-mentioned 720 DPI mode.

[0057]

Fig. 8 schematically illustrates one example of this mode. In the example illustrated in Fig. 8, the large, medium and small ejection amount modes are switched depending upon the multi-value data for each of the ejection openings to be used in 720 DPI printing. By this, printing of four values can be performed with respect to a pixel of 720 DPI. It should be noted that, in this case, the use of the recording medium having a small bleeding ratio in consideration of dispersion of the ink dot enables more linear four value expression of gradation.

[0058]

Fig. 9 schematically illustrates the dot pattern in another example of the multi-value printing mode.

[0059]

In this example illustrated in Fig. 9, dots according to multi-value data of a pixel of 360 DPI is formed with ejection openings to be used in 720 DPI mode. More specifically, two ejection openings are used for one pixel and an ejection timing corresponds to 720 DPI mode printing, to thus permit formation of four dots at the maximum. By this, the printing can be achieved at a greater number of tone levels.

[0060]

In this manner, an image having tone levels greater than usual can be printed in the pixel density of 360 DPI. Similarly, even in the pixel density of 240 DPI, an image can be printed at the increased number of gradation levels by means of the ink-jet head in the present embodiment.

[0061]

As set forth above, according to the present embodiment, basic mode printing at each of 720 DPI, 360 DPI and 240 DPI as printing modes and various modes using the basic modes can be performed. As another modification, it may be possible to print an image at a different printing density on the same

recording medium by using one of the three basic printing modes in each scanning cycle.

[0062]

It should be noted that while the ink-jet head having the maximum ejection opening density (resolution) of 720 DPI has been exemplified in the above embodiment, the maximum ejection opening density is not limited to the example. In the case where, for instance, an ink-jet head having a maximum ejection opening density of 600 DPI, it is desirable to provide 200 DPI mode and 300 DPI mode as other basic modes.

[0063]

Further, it may be possible to set the ejection amounts at a smaller value in each of the ejection amount modes so as to adjust the ejection amount in each of the ejection amount modes by a device for varying the ink-jet temperature.

[0064]

(Head Drive Control)

Among various printing modes, it is possible to vary the ejection amount mode during printing for one line, like in the multi-value printing mode. More specifically, during printing for one line, ink ejection is performed successively through the same ejection opening depending upon the dot data, wherein the ejection amount can be varied during successive ejection. On the other hand, as in the present

embodiment, when the ink ejection amount is varied by using a plurality of heaters, the variation range of the ink ejection amount is relatively large. Therefore, the ejection speed is variable depending upon the ink ejection amount. Specifically, the larger the ejection amount, the higher the ejection speed.

[0065]

Accordingly, when the ejection amount mode is varied during printing for one line, the position to deposit the ejected ink can be shifted depending upon the magnitude corresponding to variation of the ejection speed and the carriage speed. Therefore, in the present embodiment, the drive timing of the ink-jet head is varied for varying the ejection timing depending upon the ejection amount mode.

[0066]

Fig. 10(A) shows a waveform of one example of the ejection timing. This example is to establish the synchronization of a leading edge of the ejection timing pulse in the large ejection amount mode with a trailing edge of a reference clock. On the other hand, in the medium ejection amount mode and the small ejection amount mode, the ejection timing pulses are shifted depending upon the ejection amounts, respectively. By this, the center positions of the

large, medium and small dots can be aligned at the predetermined position.

[0067]

It is clear that the ejection amount mode to be synchronized with the reference clock is not limited to the example, because the ejection timing between the respective ejection amount modes encounters a problem in shifting amount, and ejection timing per se is relative.

[0068]

Incidentally, the head drive control shown in Fig. 10(A) is to vary the timing of the signal pulse between successive ejections, and thus, requires relatively complicate circuit construction. In addition, as set forth above, the head drive control is a control in the case where the ejection amount mode is varied during printing for one line, for example. In contrast to this, in a multi-pass printing method which will be discussed with reference to Fig. 11 and subsequent drawings, the ejection amount mode for each ejection opening is not varied during printing for at least one line. Therefore, a construction for shifting the ejection timing can be made simpler.

[0069]

Fig. 10(B) shows a waveform showing an ejection timing pulse in the above-described case.

[0070]

The example is to set the timing in the large ejection amount mode by the initial setting. More specifically, the initial ejection timing pulse in one line is synchronized with the trailing edge of the reference clock. In contrast to this, when the medium ejection amount mode or the small ejection amount mode is set during paper feeding (line feeding), the initial ejection timing is controlled to be advanced with respect to the reference clock, and subsequently, the ejection timing is controlled at the same interval as in the large ejection amount mode.

[0071]

Figs. 11 to 20 schematically illustrate multi-pass printing methods by using the ink-jet head in the above-described embodiment. The multi-pass printing method in the present embodiment is to perform ink ejection from a plurality of ejection openings in different scanning cycles. When this printing method is implemented in the present embodiment, the dot to be formed in one scanning cycle becomes one of large, medium and small dots. At this time, when multi-value data with large and small dots (three values by large and small dots in one pixel in 720 DPI × 720 DPI) is to be printed, for example, by forming a large dot in the forward scanning of printing and forming a small dot in the reverse scanning of printing. By this,

even when the respective colors of ink-jet heads are arranged in the scanning direction as in the present embodiment, no color fluctuation is caused and an image with high gradient can be attained.

[0072]

Fig. 11 illustrates a first example of the multi-pass printing in the present embodiment.

[0073]

As shown in Fig. 11, in the ejection opening array, the odd-numbered ejection openings are set to drive the large heater SH2 (see Fig. 4) to form a large dot, and the even-numbered ejection openings are set to drive the small heater SH1 (see Fig. 4) to form a small dot. The paper feeding (line feeding) magnitude is set to be a half of the length of the ejection opening array.

[0074]

It should be noted that in Fig. 11, the number of ejection openings is ten for the convenience of explanation. Also in Fig. 11, the ejection openings in the large and small ejection amount modes are illustrated by large and small circles, respectively.

[0075]

In Fig. 11, in the ink-jet head having the ten ejection openings in 720 DPI, the first, third, fifth, seventh and ninth ejection openings are set in the large ejection amount mode, and the second, fourth,

sixth, eighth and tenth ejection openings are set in the small ejection amount mode. And then, printing for one scanning cycle is performed. At this time, in the first scanning, ejection is not performed through the first to fifth ejection openings. Next, by feeding paper in a magnitude corresponding to the width of five ejection openings, scanning is repeated while the first ejection opening is located on the line where the sixth ejection opening has scanned in the immediately preceding scanning cycle. Thereafter, the paper is fed by a length corresponding to the width of the five ejection openings. By repeating this operation, printing of three values per one pixel can be performed. It should be noted that, in the second and subsequent scanning cycles, ink is ejected through all of the ejection openings, i.e., the ten ejection openings.

[0076]

Considering only one color, the printing method shown in Fig. 11 is three-value expression to express one pixel with or without formation of the large dot or the small dot, and a plurality of dots are never formed on the same pixel. As set forth, the printing is performed in two scanning cycles with different two ejecting openings for one line, thereby reducing fluctuations of density due to non-uniformity of

ejection characteristics of each of the ejection openings.

[0077]

Furthermore, as in the present embodiment, when color printing is to be performed and if the ink-jet heads of respective colors are arranged in the scanning direction, even when this printing method is performed in reciprocal scanning, variation of the order of ejection of the ink colors in the pixel array in the sub-scanning direction is caused for each pixel. Therefore, difference of the order appears as relatively small unit so that banding (color fluctuation) is difficult to perceive visually. Thus, with making the advantage of the reciprocal printing, high speed printing becomes possible.

[0078]

In addition, while the foregoing discussion has been given of the case where the paper feeding width (the relative shifting width of the head) is set at a half of the ejection opening array, when the number of ejection openings is 4N (N is a natural number), assuming that the number of ejection openings to be used is $2 \times (2N-1)$, the paper feeding width may be 2N-1.

[0079]

On the other hand, the number of ejection openings of the ink-jet head represents the number of

only ejection openings to be used for ink ejection. For example, even if the actual number of ejection openings is 15, it is possible to use only 10 of the 15 ejection openings for ejection.

[0080]

Fig. 12 illustrates a second example of the multi-pass printing of large and small dots.

[0081]

As shown in Fig. 12, in the ink-jet head having 8 ejection openings, large dots are formed by first, third, fifth and seventh ejection openings and small dots are formed by second, fourth sixth and eighth ejection openings.

[0082]

More specifically, in the first scanning cycle, large or small dots are formed with all of the ejection openings except for first to third ejection openings. The paper is fed by a length equivalent to the three scanning openings, and then, second scanning cycle of printing is performed. Subsequently, by feeding the paper by a length equivalent to the width of the five ejection openings. Thereafter, similar printing is repeated per two scanning cycle. In this printing, paper feeding for all of the eight ejecting openings is performed twice in paper feeding.

[0083]

With the method set forth above, it becomes possible to reduce the number of ejection openings not to be used in the first scanning cycle.

[0084]

Fig. 13 illustrates a third example of the multi-pass printing method. Here, the ink-jet head having 10 ejection openings is used as an example. In this case, the large dots are formed by first, third, fifth, seventh and ninth ejection openings and the small dots are formed by second, fourth, sixth, eighth and tenth ejection openings.

[0085]

At first, in the first scanning cycle, printing is performed by using all of the ejection openings. Subsequently, paper is fed by a length equivalent to ten ejection openings to perform a second scanning cycle. And then, backward paper feeding by the width of 11 ejection openings is performed. Thereafter, a third scanning cycle is performed. At this time, the first ejection opening is not used. Next, the paper is fed by the width of ten ejection openings. Thereafter, the printing operation is performed in a fourth scanning cycle. After completion of the paper feeding, printing in the fourth scanning cycle is performed. After the fourth scanning cycle, the paper is fed by the width of the 11 ejection openings, and

then, the printing operation is performed in the fifth scanning cycle.

[0086]

Subsequently, the three-value printing can be performed by repeating the above-described operation, i.e., once backward paper feeding by the length equal to or greater than the width of all of the ejection openings and three times paper feeding by the length equal to or greater than the width of the all of the ejection openings. By the paper feeding four times in the above-described example, the paper is fed by the length equivalent to 20 ejection openings. Namely, the paper is fed in effect by the width of the 10 ejection openings (the width of printing in one scanning cycle) by the twice paper feeding.

[0087]

Fig. 14 illustrates a further example of operation for feeding paper in the backward direction as set forth above.

[0088]

As shown in Fig. 14, similarly to the foregoing, among 10 ejection openings, the odd-numbered ejection openings are driven in the large ejection amount mode and the even-numbered ejection openings are driven in the small ejection amount mode. By repeating a printing cycle which includes twice paper feeding by the width of the 10 ejection openings and once

backward paper feeding by the width of the 5 ejection openings, and three scanning cycles during the paper feeding. With this example, printing is performed by one paper feeding by the width of the 5 ejection openings in average.

[0089]

Fig. 15 illustrates another example of the multi-pass printing including operation for feeding the paper in the backward direction.

[0090]

As shown in Fig. 15, four times feeding by the width of the 10 ejection openings, once backward feeding by the width of the 15 ejection openings, and five times scanning in total during the paper feeding are taken as one printing cycle. By repeating the printing cycle, similarly to the foregoing, printing can be performed by paper feeding by the width of the five ejection openings in average.

[0091]

When the examples of Figs. 13 to 15 are generalized as 2k (k is a natural number of one or greater) times of paper feeding by the width of the 2n ejection openings, once backward feeding by the width of (2k-1) ejection openings, and (2k+1) times scanning during the paper feeding. By repeating this printing cycle, printing with three values per pixel can be performed.

[0092]

In the multi-pass printing as set forth above, since the adjoining portion of the ink-jet head to be a boundary of the image per scanning cycle can be dispersed per half of the head width (in the case of Figs. 14 and 15), the adjoining portion becomes inconspicuous, and further, fluctuations in density cannot be perceived.

[0093]

When k is set to be greater than or equal to 2, the same line is not printed in the successive scanning cycles, so that printing of good quality becomes possible even when the recording medium has a relative low ink absorption.

[0094]

The multi-pass printing as set forth above is directed to form large and small dots. Hereinafter, a description will be given of printing of multi-value data of large, medium and small dots (four values of large, medium and small dots in one pixel in 720 DPI × 720 DPI) with reference to Figs. 16 to 20.

[0095]

Fig. 16 illustrates a first example.

[0096]

As set forth above, by switching the heater or heaters to be driven, in the order of the ejection opening array, the ejection opening having the

ejection opening number, the remainder of division by three being 1, is set in the large ejection amount mode. Similarly, the ejection opening having the ejection opening number, the remainder of division by three being 2, is set in the medium ejection amount mode and the ejection opening having the ejection opening number, the remainder of division by three being 0, is set in the small ejection amount mode. In the first scanning cycle, the printing is performed such that a large dot line, a medium dot line and a small dot line are repeated in order as shown in Fig. 16. In the next scanning cycle, small dots are formed on the line where the large dots are formed in the immediately preceding scanning cycle. And then, in the further next scanning cycle, the medium dots are formed on the line where the small dots are formed in the immediately preceding scanning cycle. Thus, respective pixels on the line are formed with or without any one of the large, medium and small dots. Thus, multi-tone expression becomes possible.

[0097]

More specifically, in the ink-jet head having twelve ink-jet openings as shown in Fig. 16, first, fourth, seventh and tenth ejection openings are set in the large ejection amount mode; second, fifth, eighth and eleventh ejection openings are set in the medium ejection amount mode; and third, sixth, ninth and

twelfth ejection openings are set in the small ejection amount mode.

[0098]

After performing printing in the first scanning cycle, paper feeding is performed by the width of the four ejection openings. Thus, the first ejection opening opposes the line where medium dots are formed by the fifth ejection opening in the first scanning cycle. Then, printing in the second scanning cycle is performed. Subsequently, printing operation is repeated by feeding the paper by the width of the four ejection openings. Thus, a four value image, in which each pixel has a large dot, a medium dot, a small dot or no dot, can be obtained.

[0099]

It should be noted that, in the foregoing example, ejection of ink is not performed through the first to eighth ejection openings in the first scanning cycle and through the first to fourth ejection openings in the second scanning cycle.

[0100]

Thus, paper feeding by the width of all of the ejection openings (the twelve ejection openings) can be done three times. Here, since paper feeding is performed by the width of the ejection openings arranged at equal intervals, density fluctuations and

seaming streaks may not be perceptible to achieve a high quality printed image.

[0101]

Fig. 17 illustrates a second example of multi-pass printing using the large, medium and small ejection amount modes.

[0102]

Here, an example of the ink-jet head having nine ejection openings is illustrated. The first, fourth and seventh ejection openings are set in the large ejection amount mode; the second, fifth and eighth ejection openings are set in the medium ejection amount mode; and the third, sixth and ninth ejection openings are set in the small ejection amount mode. After printing in the first scanning cycle, paper is fed by the width of one ejection opening, so that printing is performed in the second scanning cycle. Again, paper is fed by the width of one ejection opening and printing of the third scanning cycle is performed. Next, paper feeding by the width of seven ejection openings is performed to repeat the foregoing printing process. Through this, an image having four values per pixel can be obtained.

[0103]

In this method, while highly precise paper feeding by the width of one ejection opening is required, the number of ejection openings which do not

eject ink in the first scanning can be reduced. Thus, the image forming range becomes greater.

[0104]

Fig. 18 illustrates a third example of the multi-pass printing for forming large, medium and small dots. In this example, in the ink-jet head having nine ejection openings, one printing cycle is performed by twice paper feeding by the width of seven ejection openings and once backward paper feeding by the width of five ejection openings.

[0105]

Fig. 19 illustrates a fourth example using the ink-jet head having twelve ejection openings, in which one printing cycle is performed by twice paper feeding by the width of ten ejection openings and once backward paper feeding by the width of eight ejection openings.

[0106]

Fig. 20 illustrates a fifth example of the multi-pass printing capable of printing of large, medium and small dots.

[0107]

In this example, the ink-jet head having sixty-four ejection openings are used. However, the sixty-fourth ejection opening is constantly left unused. Here, once backward paper feeding by the width of sixty-five ejection openings and twice paper feeding

by the width of sixty-three ejection openings result in one printing cycle with paper feeding by the width of the sixty-three ejection openings by three times paper feeding. The printing is performed by repeating the foregoing printing cycles.

[0108]

(Second Embodiment)

Figs. 21(A) and 21(B) are cross-sectional views as viewed from the upper side and back side, respectively, showing the construction of an ink-jet head in a second embodiment according to the present invention.

[0109]

As shown in Fig. 21, unlike the above-described ink-jet head in the first embodiment, while small heaters are arranged in all of ejection openings, large heaters are arranged only in even-numbered ejection openings. Unlike the first embodiment, in this head construction, the construction for four value printing method for four value printing in 720 DPI × 720 DPI, and high density mode printing becomes somewhat complicated. However, other modes can be implemented substantially similarly to the first embodiment.

[0110]

Unlike the head in the first embodiment, in the second embodiment, the number of large heaters can be

reduced to a half to permit reduction of an installation space and simplification of wiring of electrodes and conductors and a heater driving circuit.

[0111]

(Third Embodiment)

Figs. 22(A) and 22(B) are cross-sectional views similar to Figs. 21(A) and 21(B), but showing the construction of an ink-jet head in a third embodiment according to the present invention.

[0112]

The ink-jet head in the third embodiment has large and small heaters alternately arranged per ink path. Furthermore, in the third embodiment, a distance EH between the ejection opening and the heater and the diameter of the ejection opening are made smaller in the ink path accommodating the small heater.

[0113]

In the third embodiment, the ejection speeds of a large ink droplet and a small ink droplet respectively ejected through the large and small ejection openings can be made constant by varying the diameter of the ejection opening. As a result, the foregoing delay control and the like per dot becomes unnecessary to form the dot substantially at the center of a pixel.

[0114]

Moreover, since the ejection speed is increased even in the small dot, a period when ink ejection is not performed can be made longer to maintain substantially normal ejection even if the viscosity of ink is somewhat increased.

[0115]

Furthermore, since the plurality of heaters are not provided in each ink path, the number of heaters or wirings can be reduced.

[0116]

(Fourth Embodiment)

Figs. 23(A) and 23(B) are cross-sectional views, similar to Figs. 22(A) and 22(B), showing the construction of an ink-jet head in a fourth embodiment according to the present invention.

[0117]

The ink-jet head in the fourth embodiment optimizes an ink path width in comparison with the second embodiment. More specifically, by increasing a sectional area of the ink path with respect to a large-diameter ejection opening, a heater size can be made greater. As a result, even when the ejection amount of ink droplets to be ejected is varied, an ejection speed can be kept substantially constant.

[0118]

Figs. 24 to 26 show other constructions of ink-jet heads to be used according to the present invention. Among these ink-jet heads, Fig. 24 shows a side shooter type ink-jet head provided with large and small heaters. On the other hand, Figs. 25 and 26 show ink-jet heads provided with heaters according to multi-pass printing.

[0119]

It should be appreciated that while the foregoing description has been given of the examples where the ink-jet heads of respective colors are arranged in the primary scanning direction, the application of the present invention should not be limited to such arrangement. For instance, the present invention is, of course, applicable to arrangement of an ink-jet head having the ejection openings of respective colors aligned in an auxiliary scanning direction (a paper feeding direction).

[0120]

Moreover, with respect to inks of different densities, the present invention is naturally applicable to the case where different ink-jet heads are used for the inks of different densities or where the ink-jet head is integrated with separated liquid chambers.

[0121]

(Others)

According to the present invention, particularly among the ink-jet recording systems, the excellent effects can be produced in the recording head or apparatus of the system provided with the means for generating thermal energy (e.g., an electrothermal transducer, a laser beam or the like) as energy utilized for performing the ink ejection so as to induce the ink state variation caused by the thermal energy, thus achieving high density and high fineness of recording.

[0122]

It is preferable that the basic principle disclosed in, e.g., U.S. Patent No. 4,723,129 or 4,740,796 should be used for the typical configuration and principle of the above-described apparatus. This system can be applicable to either an on-demand type or a continuous type. Particularly, the on-demand type is effective because at least one drive signal for rapidly increasing a temperature in excess of a film boiling point in response to recording information is applied to the electrothermal transducer arranged in a manner corresponding to a sheet holding liquid (ink) thereon or a liquid path, thereby generating thermal energy in the electrothermal transducer so as to generate film

boiling at a heat acting surface of the recording head, resulting in formation of bubbles in the liquid (ink) in one-to-one correspondence to the drive signal. Growth or contraction of the bubbles causes the liquid (ink) to be ejected through the ejection opening, thus forming at least one droplet. The drive signal in the form of a pulse is much preferable because the bubbles can grow or be contracted instantaneously and appropriately, and thus, the liquid (ink) can be ejected with remarkably high responsiveness. A signal disclosed in U.S. Patent No. 4,463,359 or 4,345,262 may be suitable for the drive signal in the form of a pulse. More excellent recording can be achieved by using conditions disclosed in U.S. Patent No. 4,313,124 relating to a temperature increasing rate at the heat acting surface.

[0123]

The configurations of the recording heads according to the present invention include the configuration disclosed in U.S. Patent No. 4,558,333 or 4,459,600 in which the heat acting surface is located in a bent region beside the configuration in which the ejection openings, the liquid paths and the electrothermal transducers are combined with each other (a linear liquid channel or a rectangular liquid channel) as disclosed in the aforementioned specifications. Additionally, the effect according to

the present invention may be produced in the configuration disclosed in Japanese Patent Application Laid-open No. 123,670/1984 in which slots common to a plurality of electrothermal transducers are used as ejection openings of the electrothermal transducers, or in the configuration disclosed in Japanese Patent Application Laid-open No. 138,461/1984 in which openings for absorbing a pressure wave of thermal energy correspond to ejection openings. That is, recording operation may be securely performed with efficiency according to the present invention irrespective of whatever the configuration of the recording head is.

[0124]

Furthermore, the recording head of a full-line type having a length corresponding to the maximum width of the recording medium which can be recorded by the recording apparatus may take either one of the configuration in which a plurality of recording heads are combined to cover the length and the configuration of one recording head formed integrally.

[0125]

Additionally, there may be used not only the recording head of the cartridge type in which an ink tank is disposed integrally with the recording head per se, as described in the above embodiment, but also a recording head of a replaceable chip type in which

the head is fixed to the apparatus body to be electrically connected to the apparatus body or ink can be supplied from the apparatus body.

[0126]

It is preferable that ejection recovering means, preliminarily auxiliary means or the like for the recording head should be additionally disposed as constituents of the recording apparatus according to the present invention, thus further stabilizing the advantageous results of the present invention. There are specifically listed capping means with respect to the recording head, cleaning means, pressurizing or sucking means, preliminarily heating means for performing heating by the use of the thermoelectric transducer, other heating elements, or the combination thereof, and preliminarily ejecting means for performing ejection other than recording.

[0127]

With respect to the kind or number of recording heads to be installed, only one recording head may be provided in a fashion corresponding to monochromatic ink, or a plurality of recording heads may be provided in a fashion corresponding to a plurality of inks different in color or concentration. That is, the present invention can be effectively applicable to recording apparatuses in not only a recording mode in only one main color such as black but also a full-

color recording mode in different or mixed colors by using either an integral ink-jet head or a plurality of recording heads in combination.

[0128]

Although the ink in the state of liquid has been explained in the above-described embodiments according to the present invention, there may be used ink which is solidified at room temperature or lower and softened or liquefied at room temperature. Otherwise, since in the ink-jet system, the temperature of the ink is generally controlled so as to keep the viscosity of the ink within a stable ejection range by adjusting the temperature of the ink per se within the range from 30 °C to 70 °C, there may be used ink which becomes liquefied at the time of application of a used recording signal. Additionally, ink which is solid in a left state while is liquefied by heating may be used in order to aggressively prevent an increase in temperature due to thermal energy which is used as energy for transforming the ink from solid to liquid, or to prevent any evaporation of the ink. Anyway, the present invention is applicable to the case using ink having a property which is first liquefied with application of thermal energy, such as ink which is liquefied with application of thermal energy in response to a print signal to be ejected in a liquid state, ink which has started to be solidified already

at the time when it reaches a medium to be printed, or the like. As disclosed in Japanese Patent Application Laid-open No. 56847/1979 or 71260/1985, such ink may be disposed opposite to the thermoelectric transducer in a manner held in a liquid or solid state in a recess or through hole formed at a porous sheet. According to the present invention, the above-described film boiling system is most effective for each of the above-described inks.

[0129]

Furthermore, the ink-jet recording apparatus according to the present invention may be used as an image output terminal for information processing equipment such as a computer, a copy machine combined with a reader, a facsimile apparatus having a transmitting/receiving function, or the like.

[0130]

[Advantageous Results of the Invention]

As is clear from the above description, according to the present invention, the ink amount to be ejected from each of the ejection openings can be variably set, and further, the printing mode according to the setting can be set.

[BRIEF DESCRIPTION OF THE DRAWINGS]

[Fig. 1]

Fig. 1 is a perspective view showing an ink-jet printing apparatus in a first embodiment according to the present invention.

[Fig. 2]

Fig. 2 is a block diagram illustrating mainly a control system of the printing apparatus.

[Fig. 3]

Fig. 3 is a cross-sectional view showing an ink-jet head and an ink tank cartridge for use in the apparatus.

[Fig. 4]

Fig. 4 is a cross-sectional view showing the structure of the ink-jet head in the first embodiment according to the present invention.

[Fig. 5]

Fig. 5 schematically illustrates dot arrangement in a high density mode in the first embodiment.

[Fig. 6]

Fig. 6 is a flowchart illustrating processing procedures in a smoothing mode in the first embodiment.

[Fig. 7]

Fig. 7 schematically illustrates the smoothing mode.

[Fig. 8]

Fig. 8 schematically illustrates dot arrangement in a multi-value mode in the first embodiment.

[Fig. 9]

Fig. 9 schematically illustrates another example of the dot arrangement in the multi-value mode.

[Fig. 10]

Figs. 10(A) and 10(B) illustrate waveforms illustrating an ejection timing in the first embodiment.

[Fig. 11]

Fig. 11 illustrates a multi-pass printing method in the first embodiment.

[Fig. 12]

Fig. 12 illustrates a multi-pass printing method in the first embodiment.

[Fig. 13]

Fig. 13 illustrates a multi-pass printing method in the first embodiment.

[Fig. 14]

Fig. 14 illustrates a multi-pass printing method in the first embodiment.

[Fig. 15]

Fig. 15 illustrates a multi-pass printing method in the first embodiment.

[Fig. 16]

Fig. 16 illustrates a multi-pass printing method in the first embodiment.

[Fig. 17]

Fig. 17 illustrates a multi-pass printing method in the first embodiment.

[Fig. 18]

Fig. 18 illustrates a multi-pass printing method in the first embodiment.

[Fig. 19]

Fig. 19 illustrates a multi-pass printing method in the first embodiment.

[Fig. 20]

Fig. 20 illustrates a multi-pass printing method in the first embodiment.

[Fig. 21]

Figs. 21(A) and 21(B) are cross-sectional views showing the construction of an ink-jet head in a second embodiment according to the present invention.

[Fig. 22]

Figs. 22(A) and 22(B) are cross-sectional views showing the construction of an ink-jet head in a third embodiment according to the present invention.

[Fig. 23]

Figs. 22(A) and 22(B) are cross-sectional views showing the construction of an ink-jet head in a fourth embodiment according to the present invention.

[Fig. 24]

Figs. 24(A) and 24(B) are cross-sectional views showing another example of an ink-jet head, to which the present invention can be applied.

[Fig. 25]

Fig. 25 is a cross-sectional view showing a further example of an ink-jet head, to which the present invention can be applied.

[Fig. 26]

Fig. 26 is a cross-sectional view showing a still further example of an ink-jet head, to which the present invention can be applied.

[REFERENCE NUMERALS]

2, 2Y, 2M, 2C, 2Bk ... ink-jet head

2A ... ink path

2N, $2N_L$, $2N_M$, $2N_S$ ... ejection opening

200 ... controller

SH1, SH2, SH3 ... heater

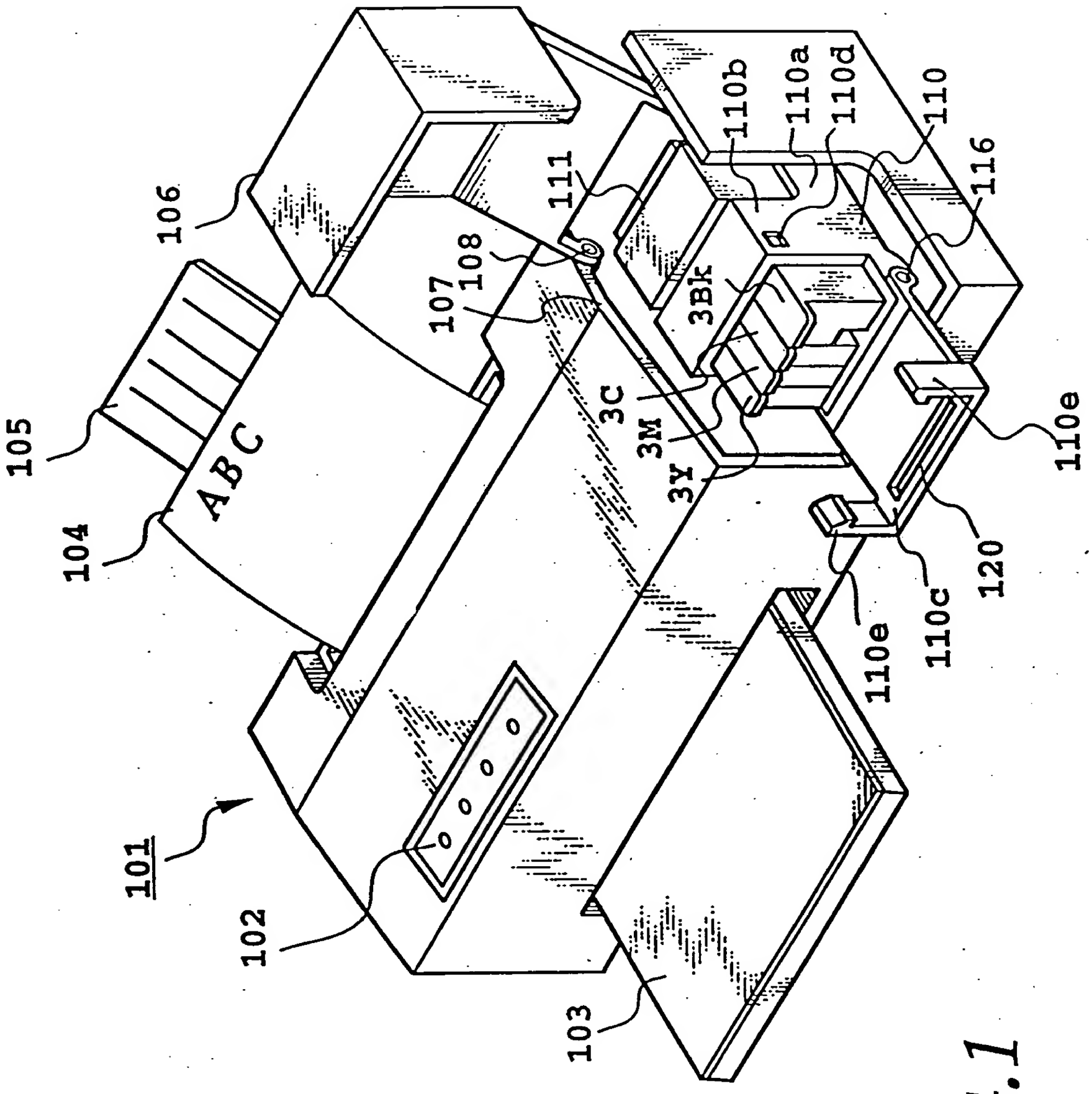

106
105
104
ABC
107
108
111
110b
110a
110d
110
116
3BK
3C
3M
3Y
110e
110c
120
110e
101
102
103

FIG. 1

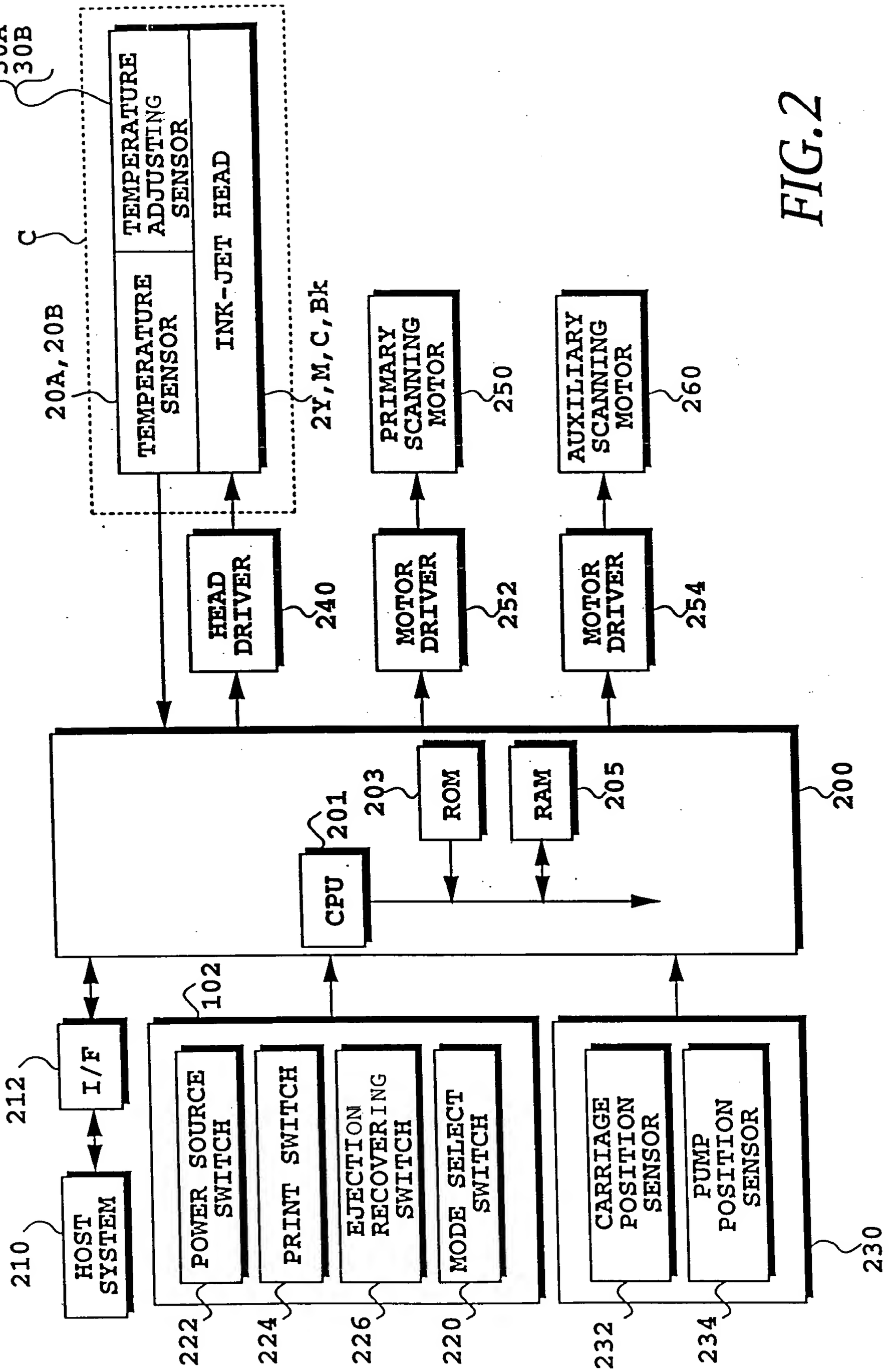

30A
30B
C
20A,20B
TEMPERATURE ADJUSTING SENSOR
TEMPERATURE SENSOR
INK-JET HEAD
2Y,M,C,Bk
PRIMARY SCANNING MOTOR
250
AUXILIARY SCANNING MOTOR
260
HEAD DRIVER
240
MOTOR DRIVER
252
MOTOR DRIVER
254
CPU
201
ROM
203
RAM
205
200
102
I/F
212
HOST SYSTEM
210
POWER SOURCE SWITCH
PRINT SWITCH
EJECTION RECOVERING SWITCH
MODE SELECT SWITCH
222
224
226
220
CARRIAGE POSITION SENSOR
PUMP POSITION SENSOR
232
234
230

FIG.2

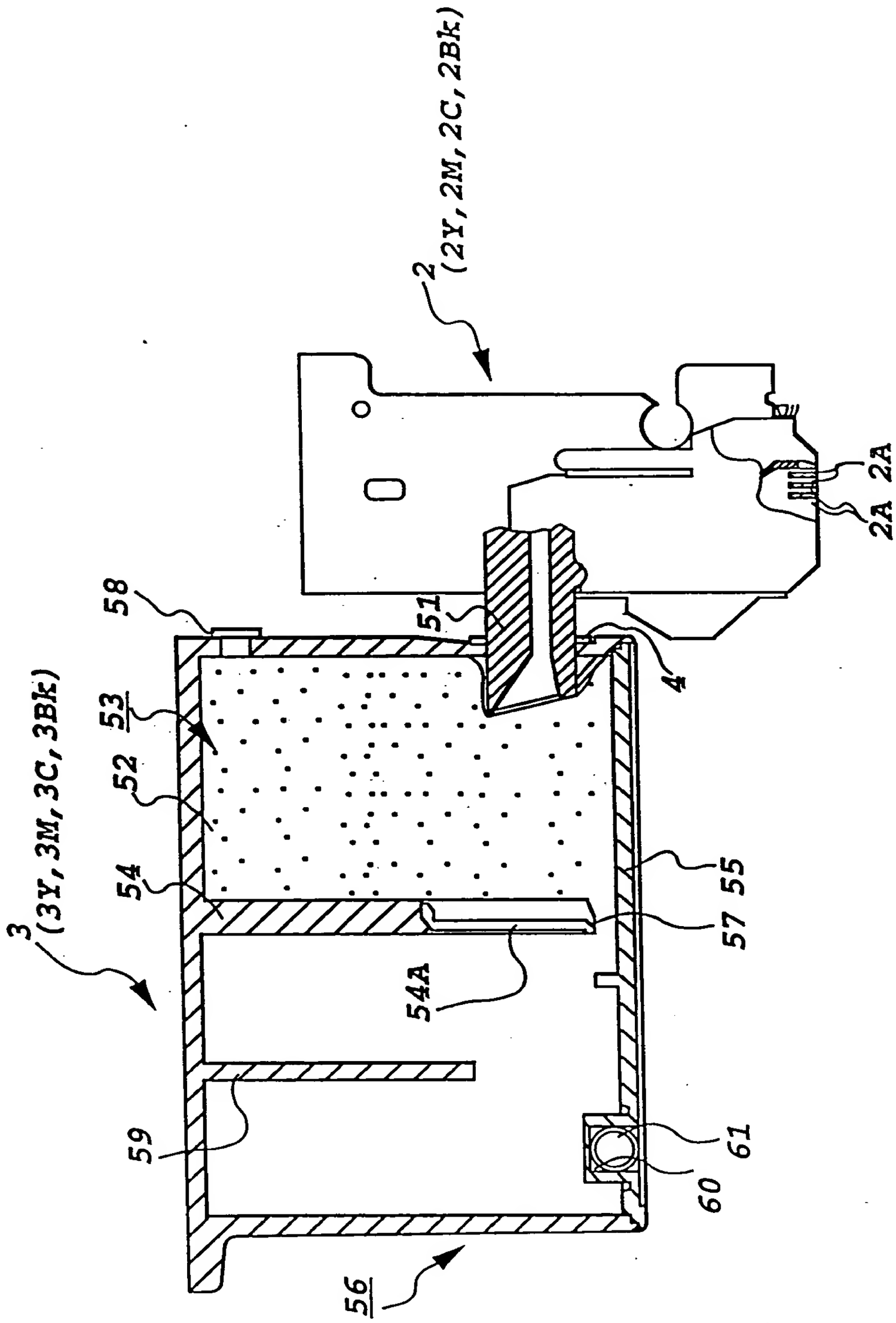

2
(2Y, 2M, 2C, 2Bk)
2A 2A
58
51
4
53
52
54
3
(3Y, 3M, 3C, 3Bk)
57 55
54A
59
61
60
56

FIG.3

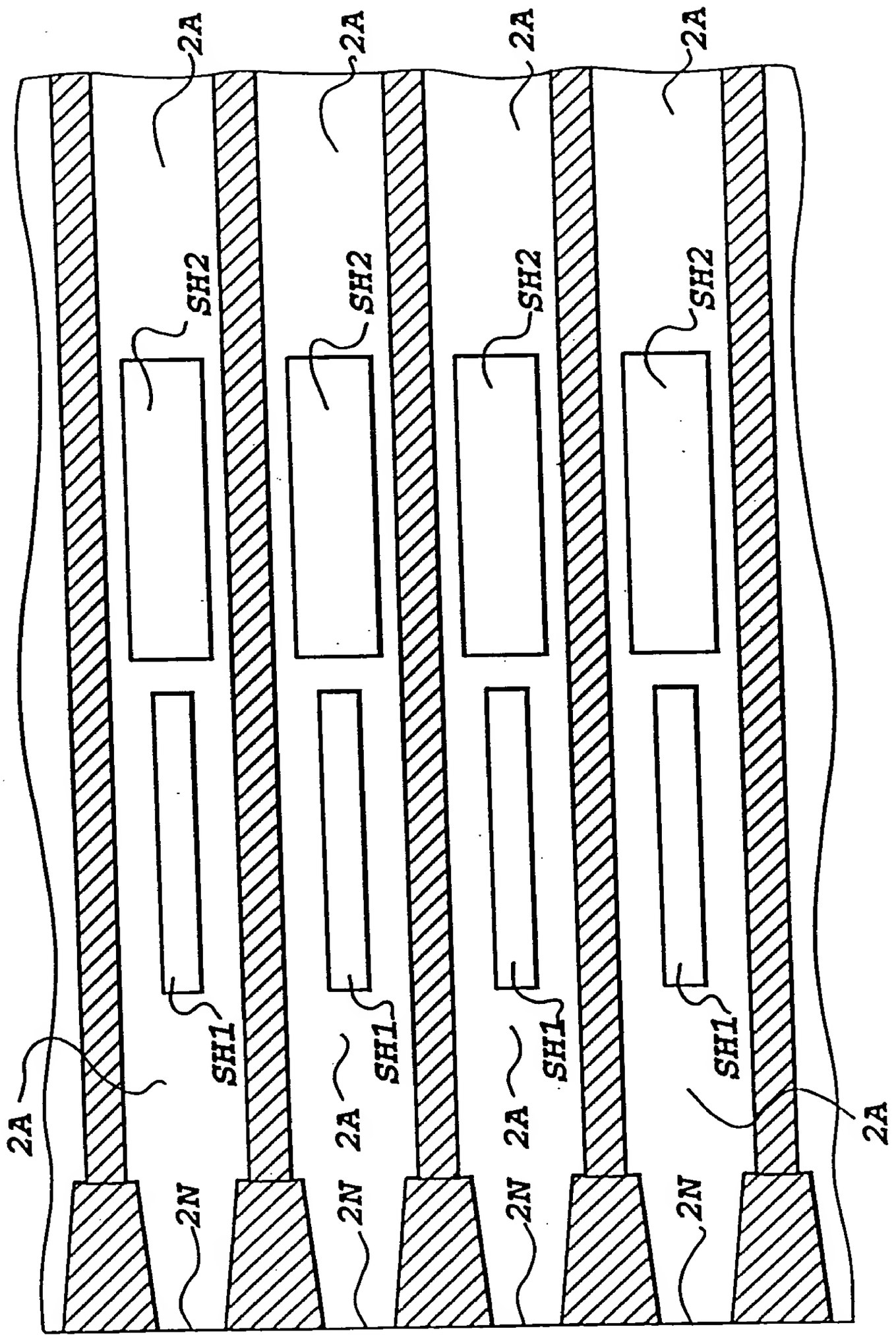


FIG.4

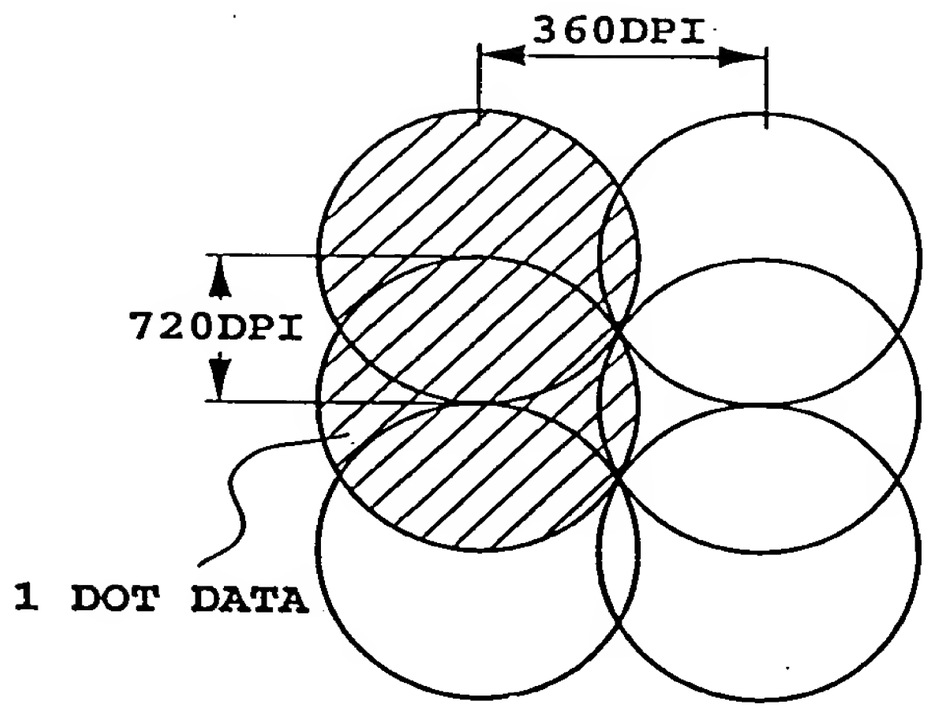

360DPI
720DPI
1 DOT DATA

FIG. 5

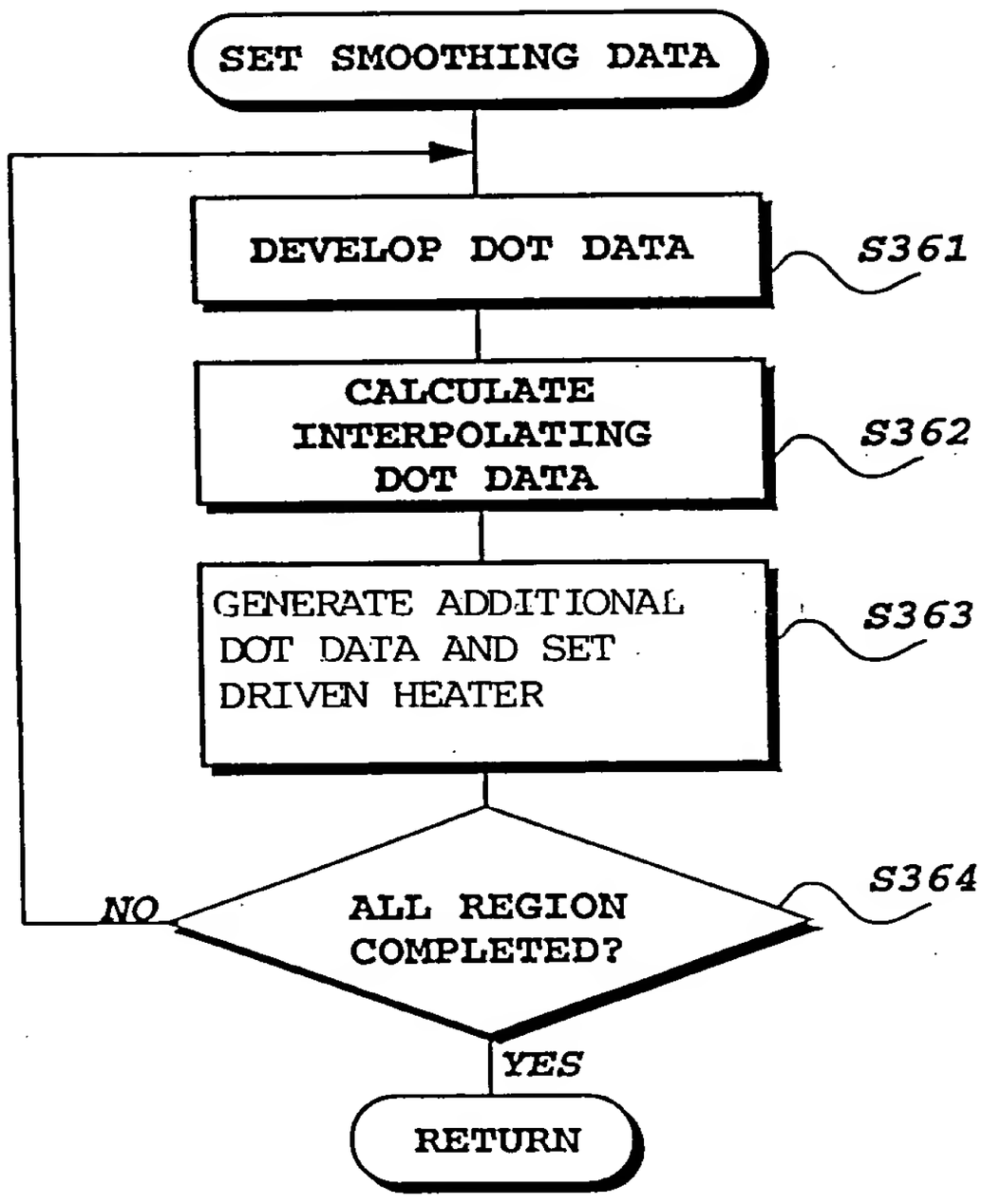

SET SMOOTHING DATA
DEVELOP DOT DATA
S361
CALCULATE INTERPOLATING DOT DATA
S362
GENERATE ADDITIONAL DOT DATA AND SET DRIVEN HEATER
S363
ALL REGION COMPLETED?
S364
NO
YES
RETURN

FIG. 6

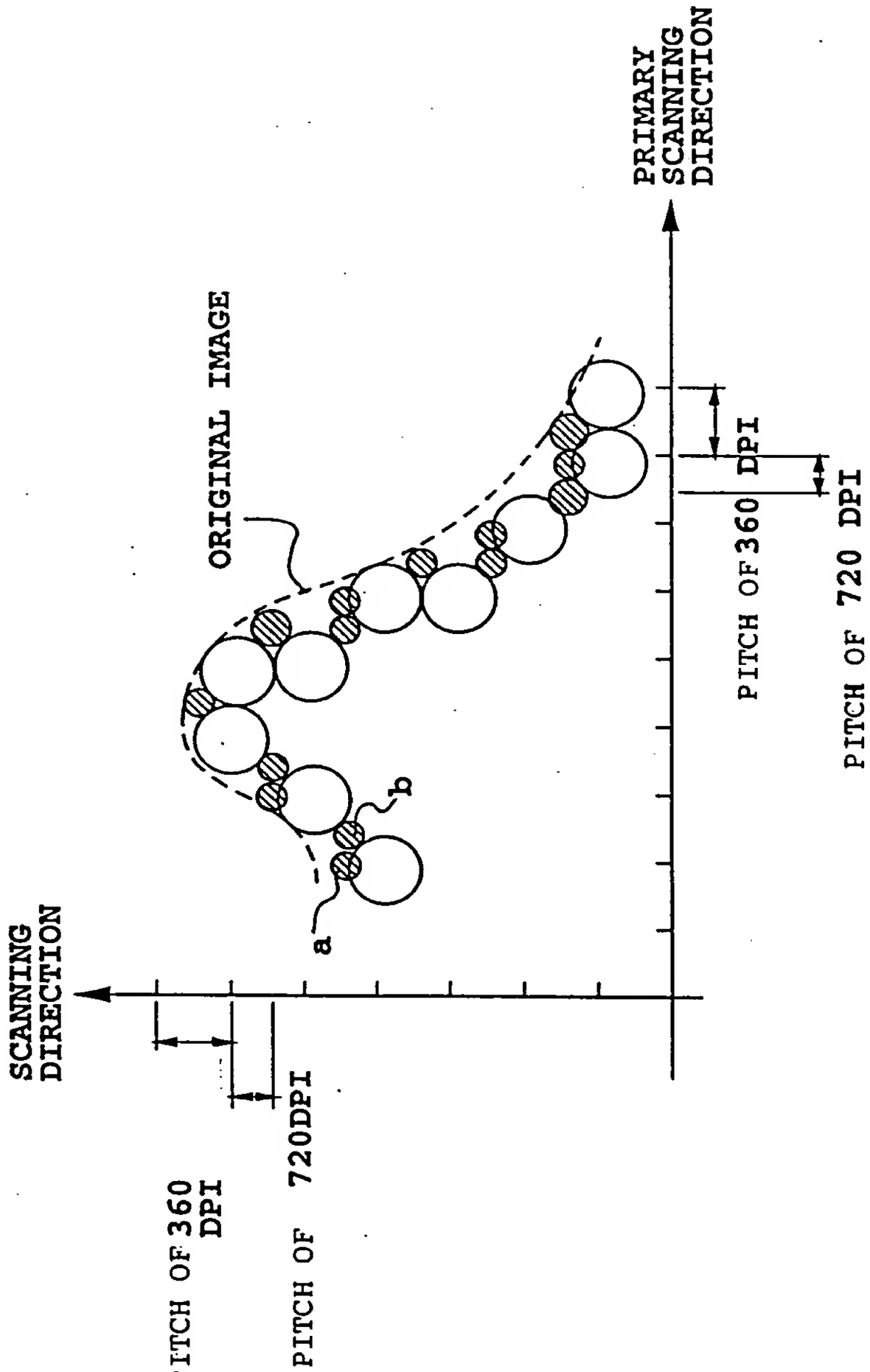
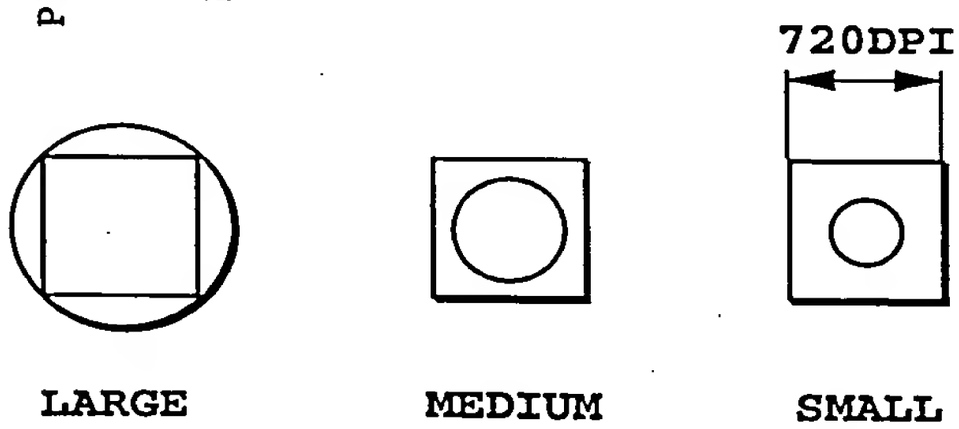

PRIMARY SCANNING DIRECTION
ORIGINAL IMAGE
a
b
SCANNING DIRECTION
PITCH OF 360 DPI
PITCH OF 720DPI
PITCH OF 360 DPI
PITCH OF 720 DPI

FIG. 7

FIG. 8


720DPI
LARGE
MEDIUM
SMALL

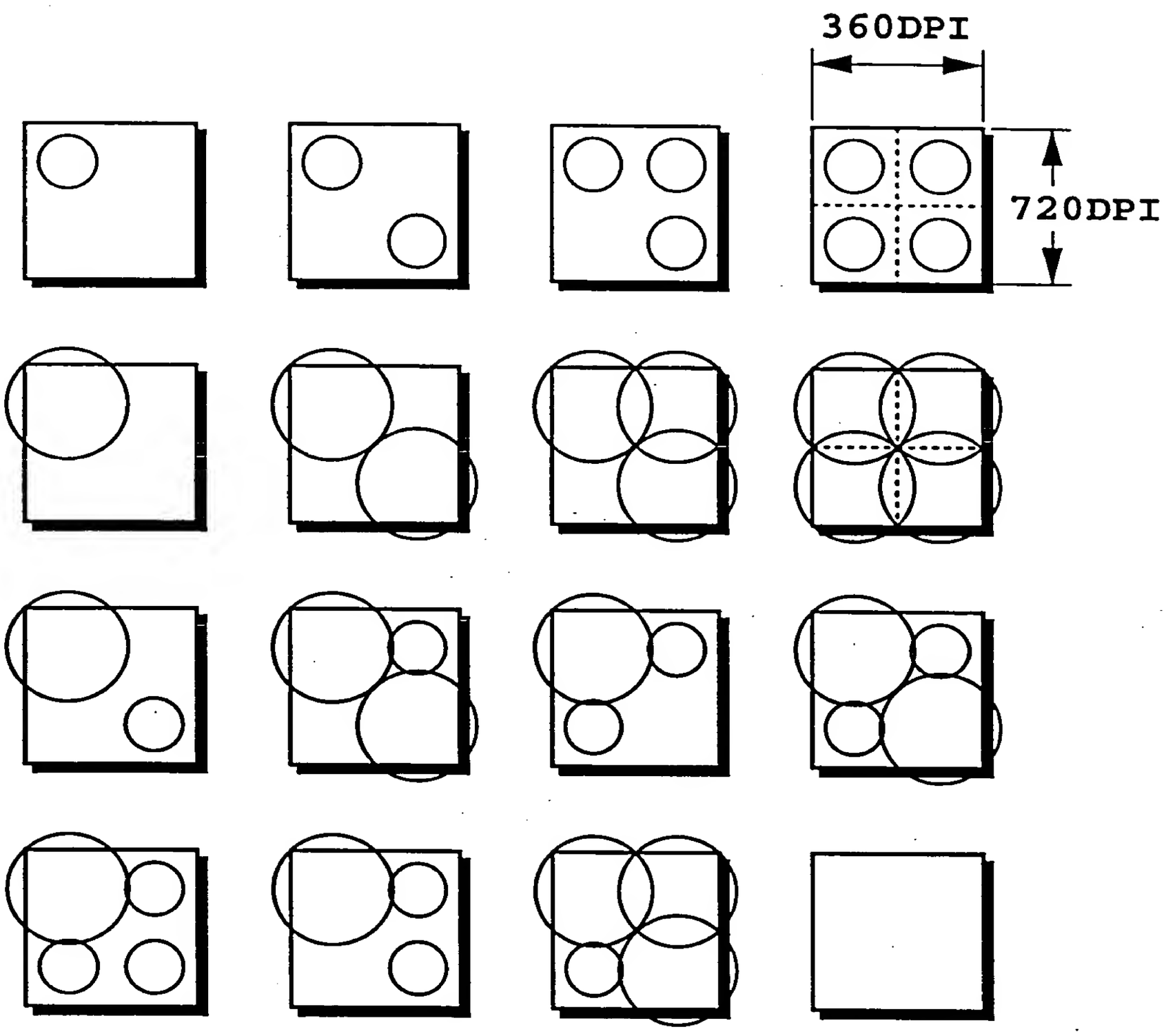


FIG. 9

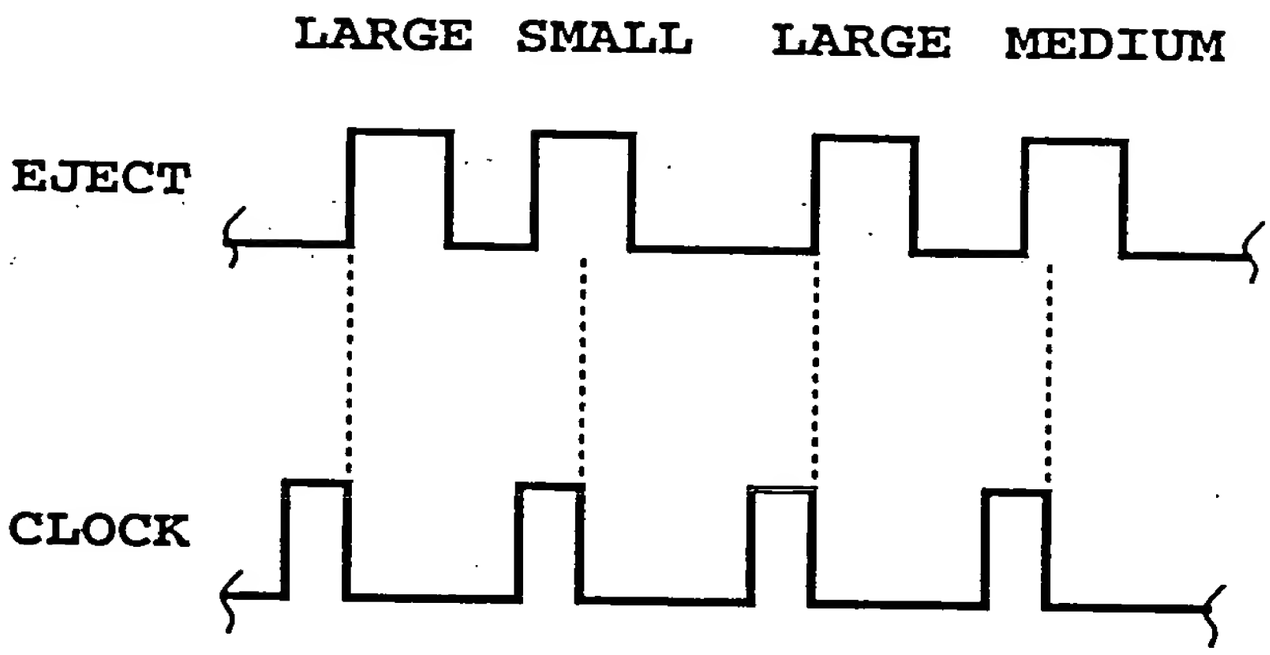


FIG. 10 (A)

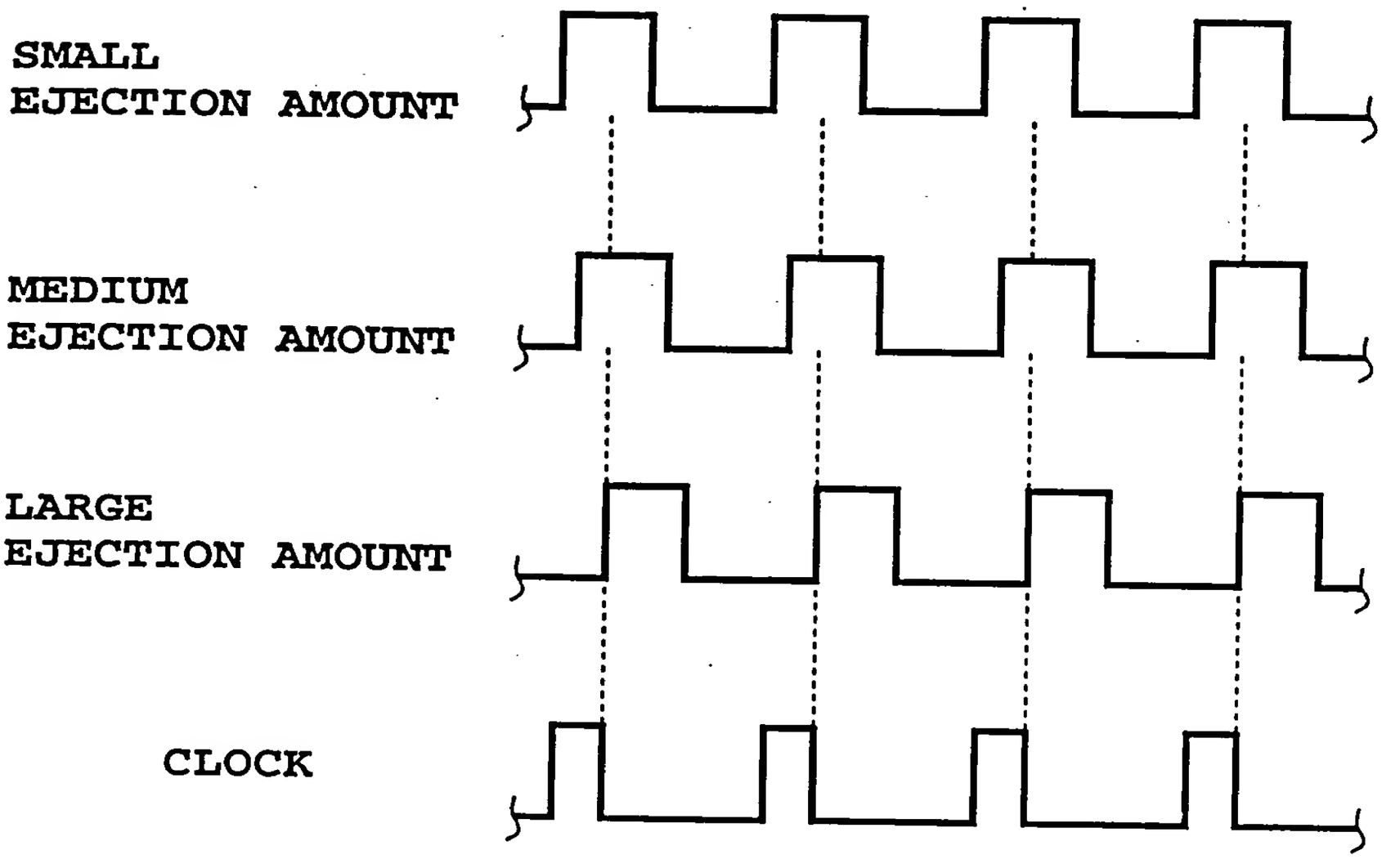


FIG.10 (B)

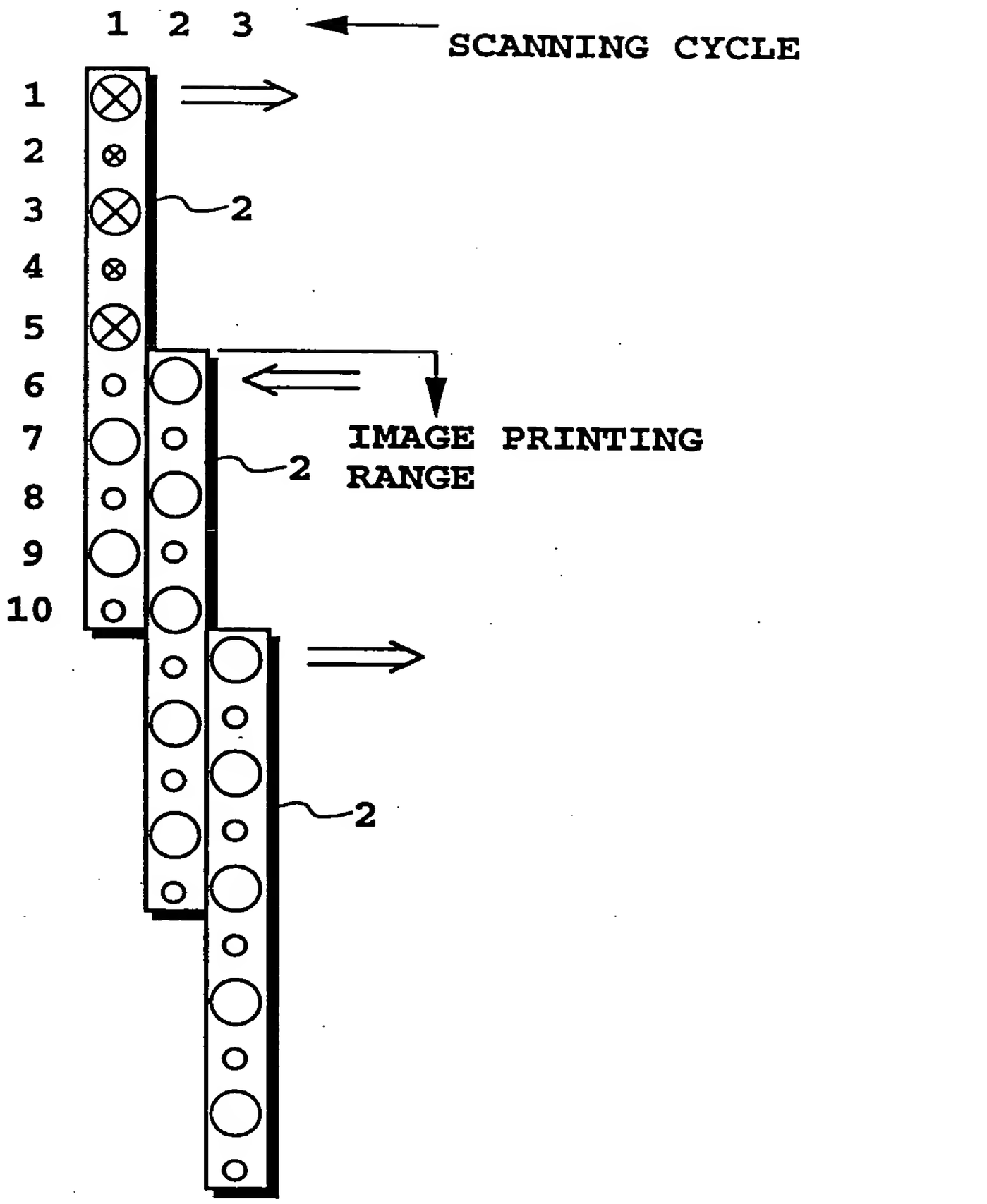

1 2 3
SCANNING CYCLE
1
2
3
4
5
6
7
8
9
10
2
IMAGE PRINTING RANGE
2
5 5 . . . . . 5 EQUAL FEEDING OF EJECTION OPENING WIDTH

FIG. 11

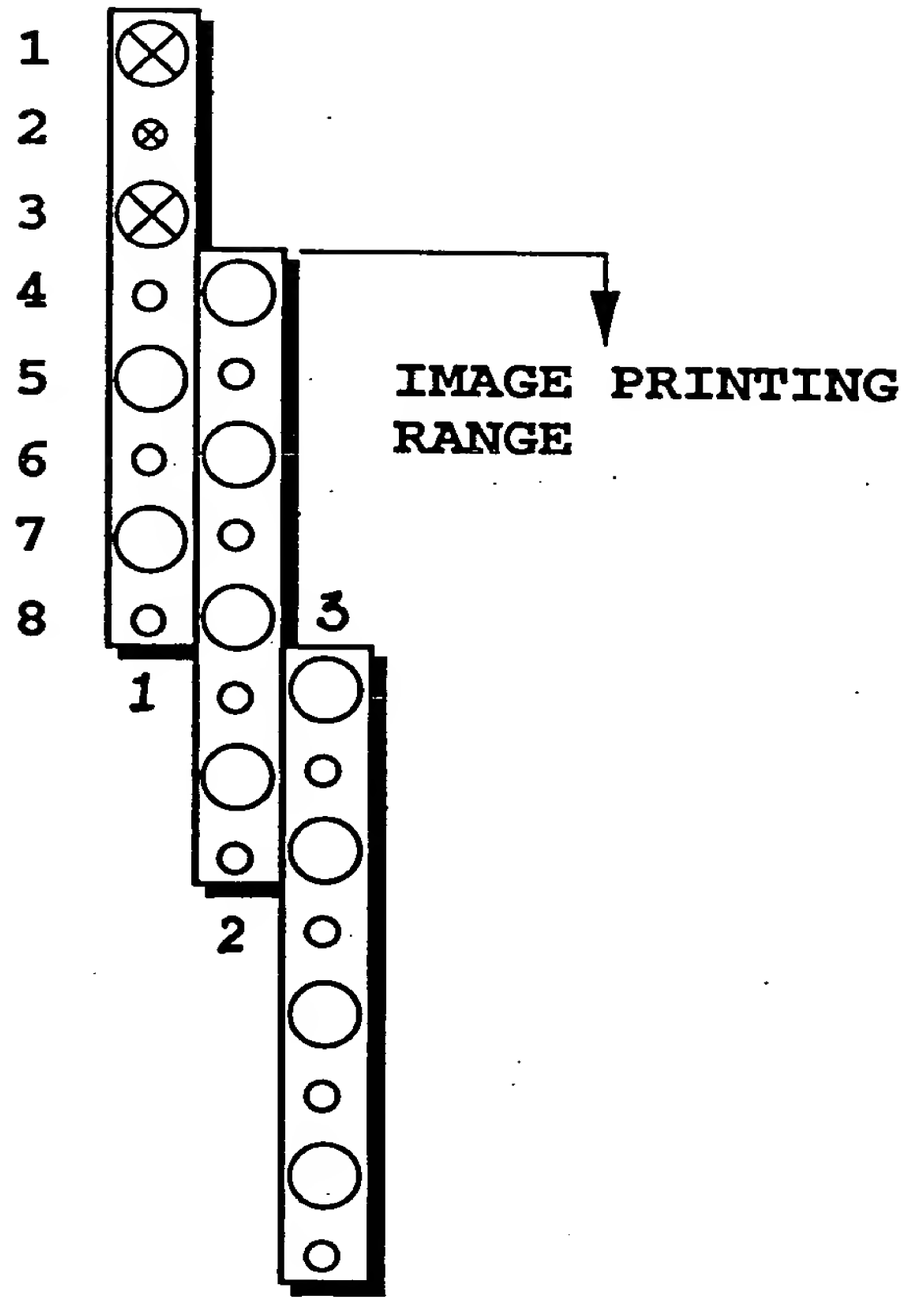


FIG. 12

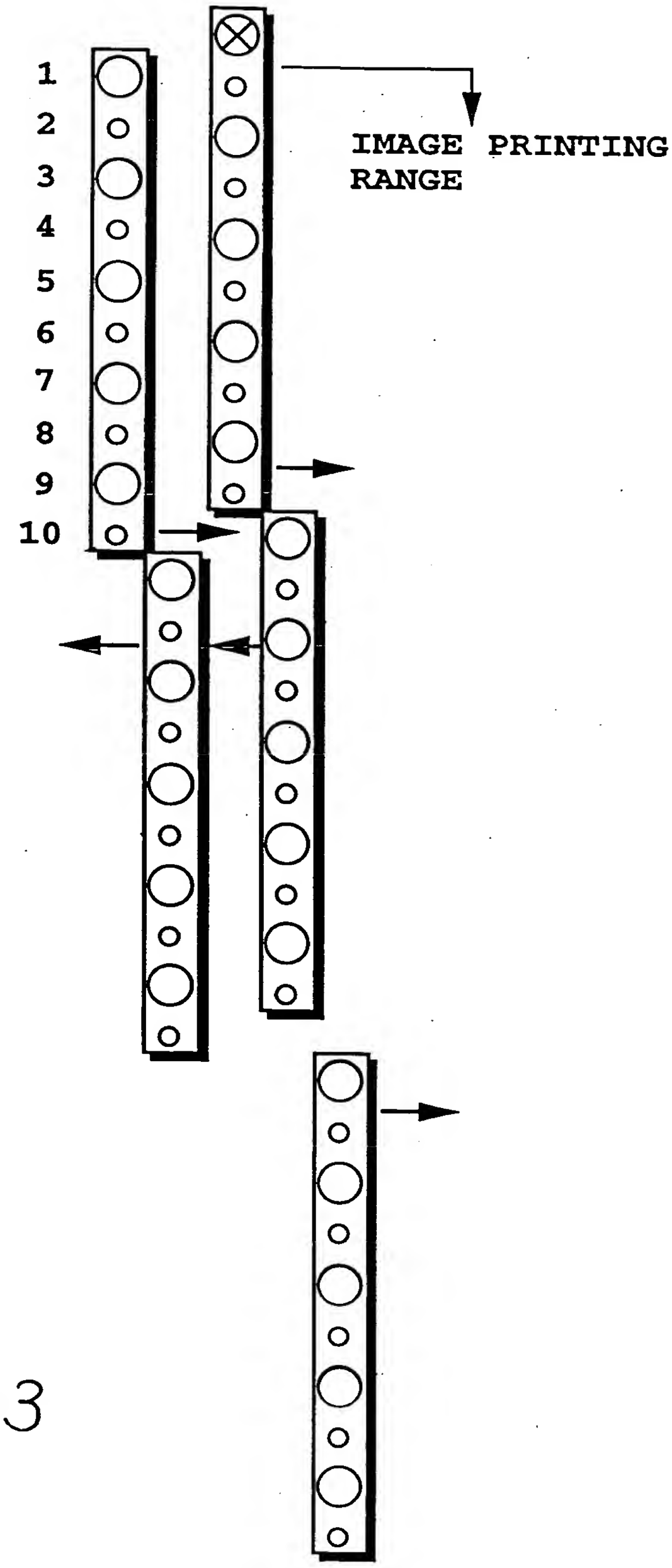


FIG. 13

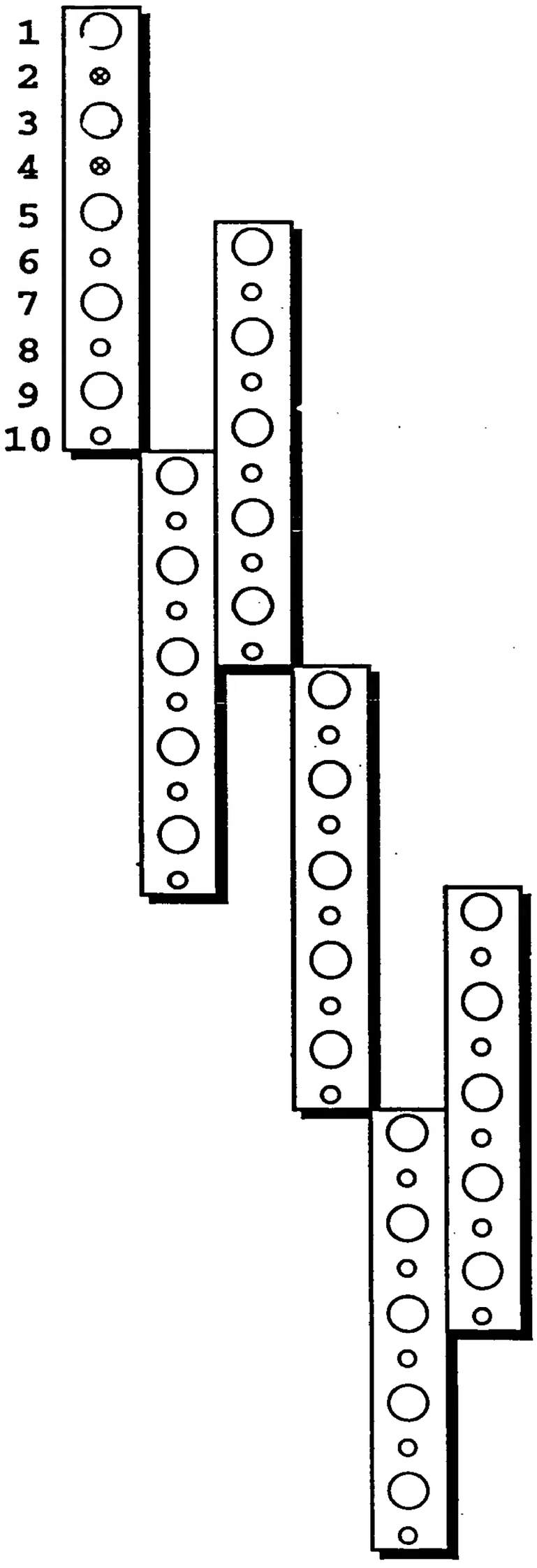
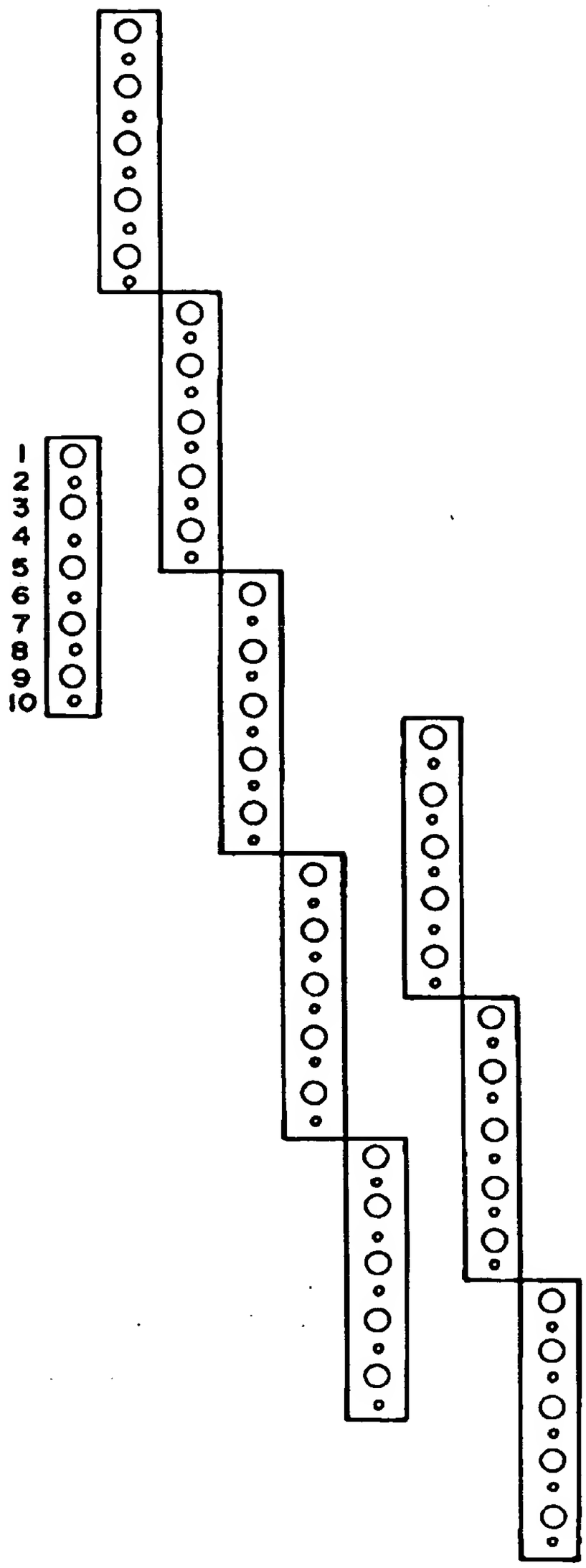


FIG. 14

FIG. 15



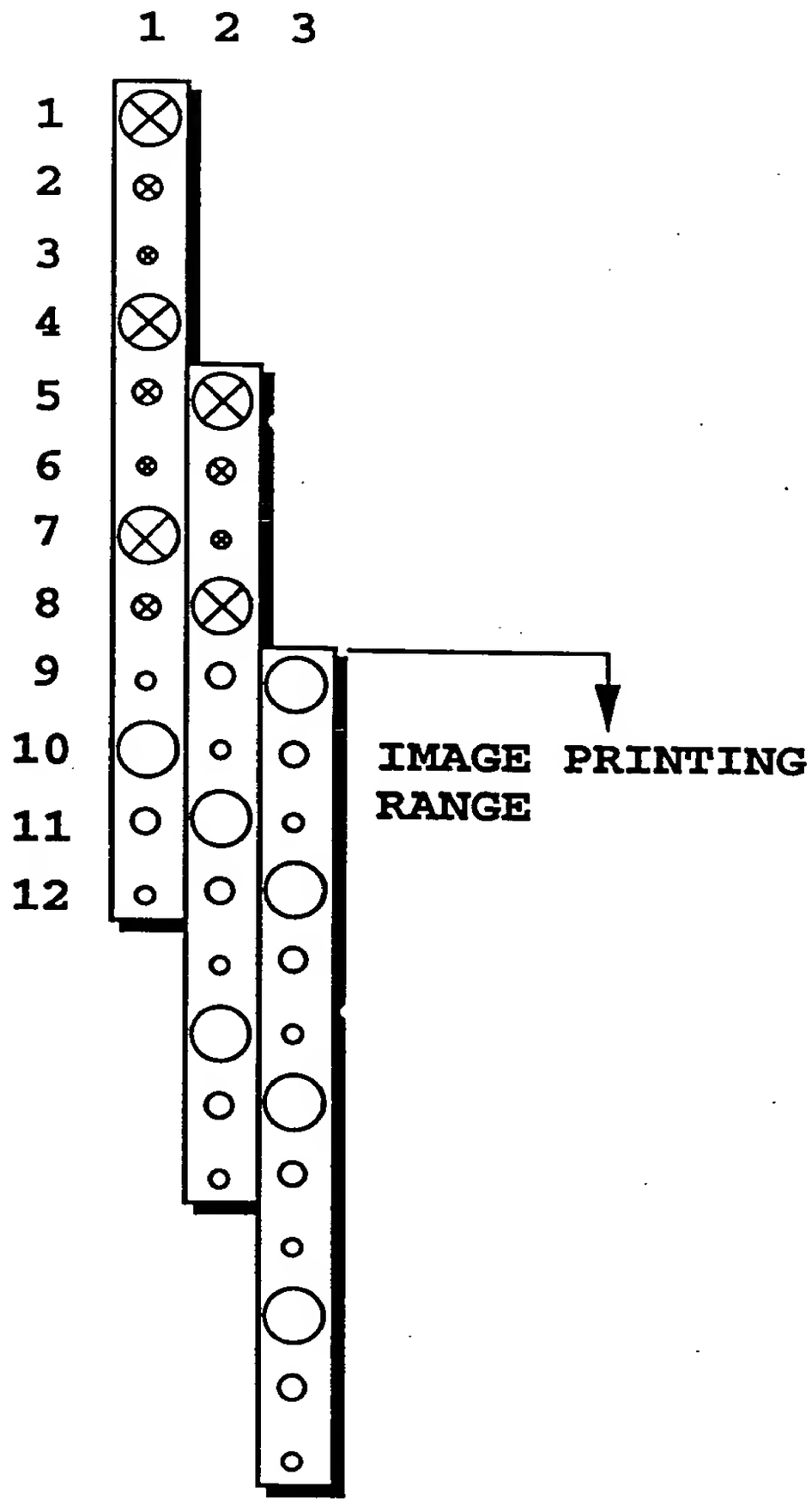


FIG. 16

FIG. 17

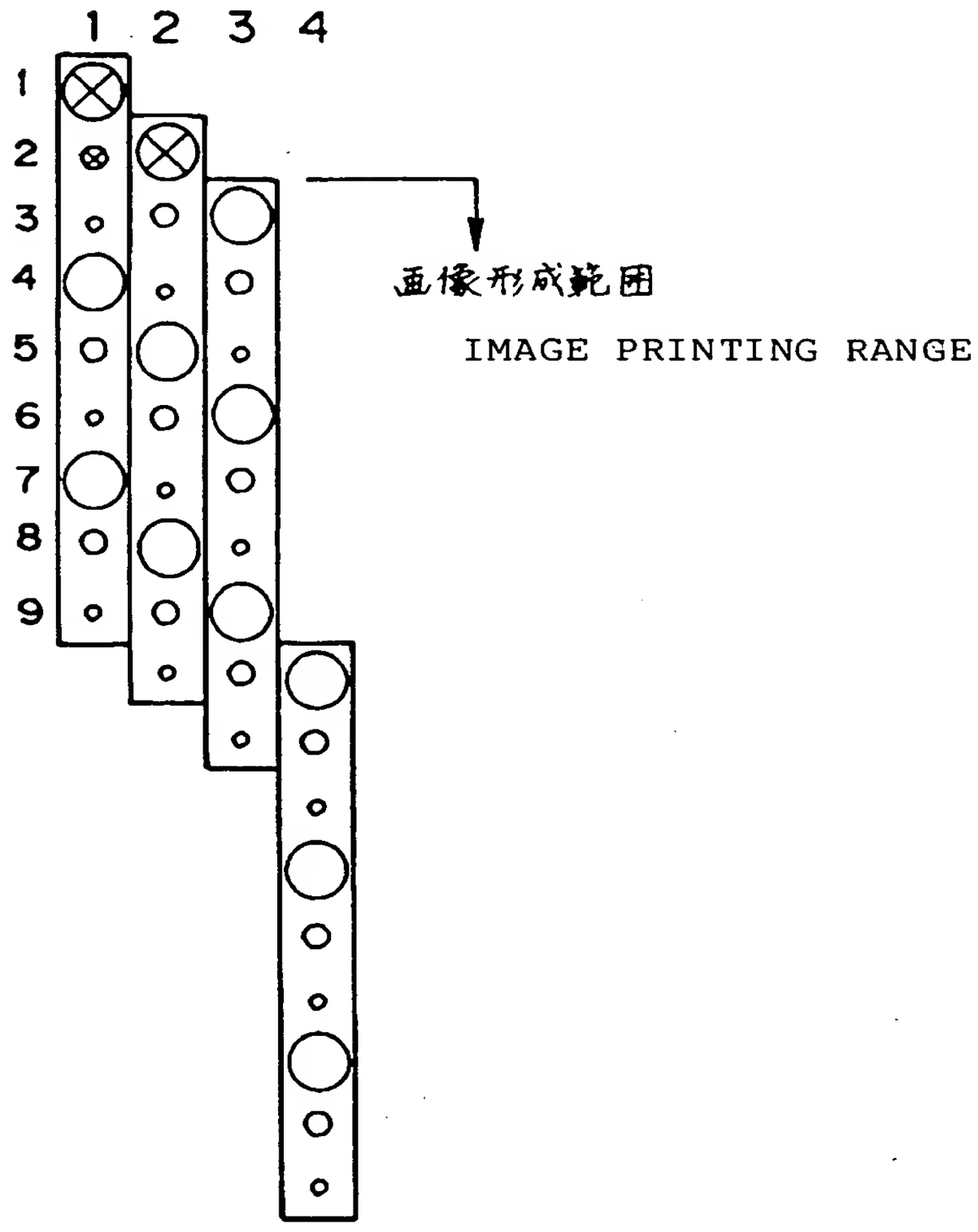


FIG. 18

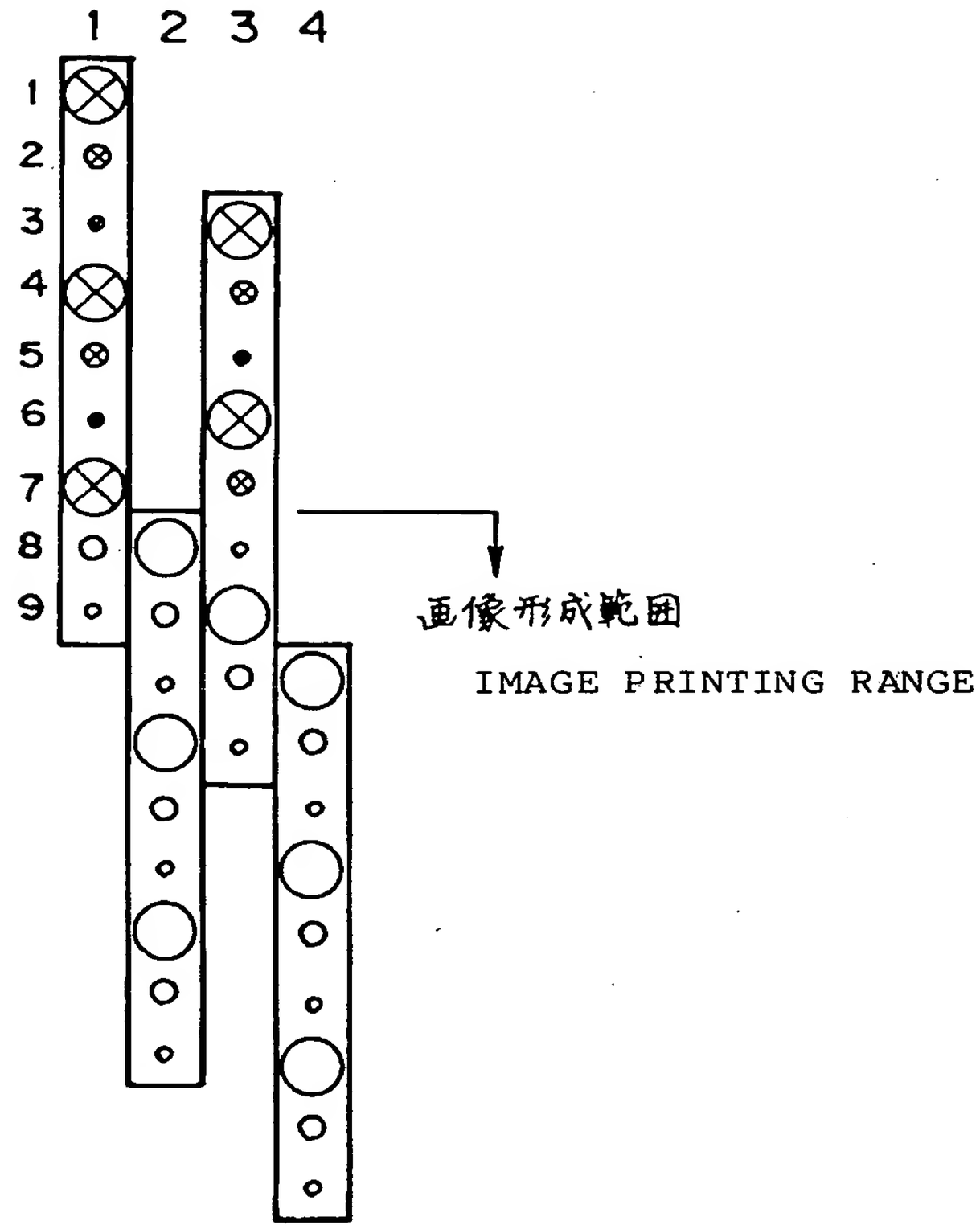


FIG. 19

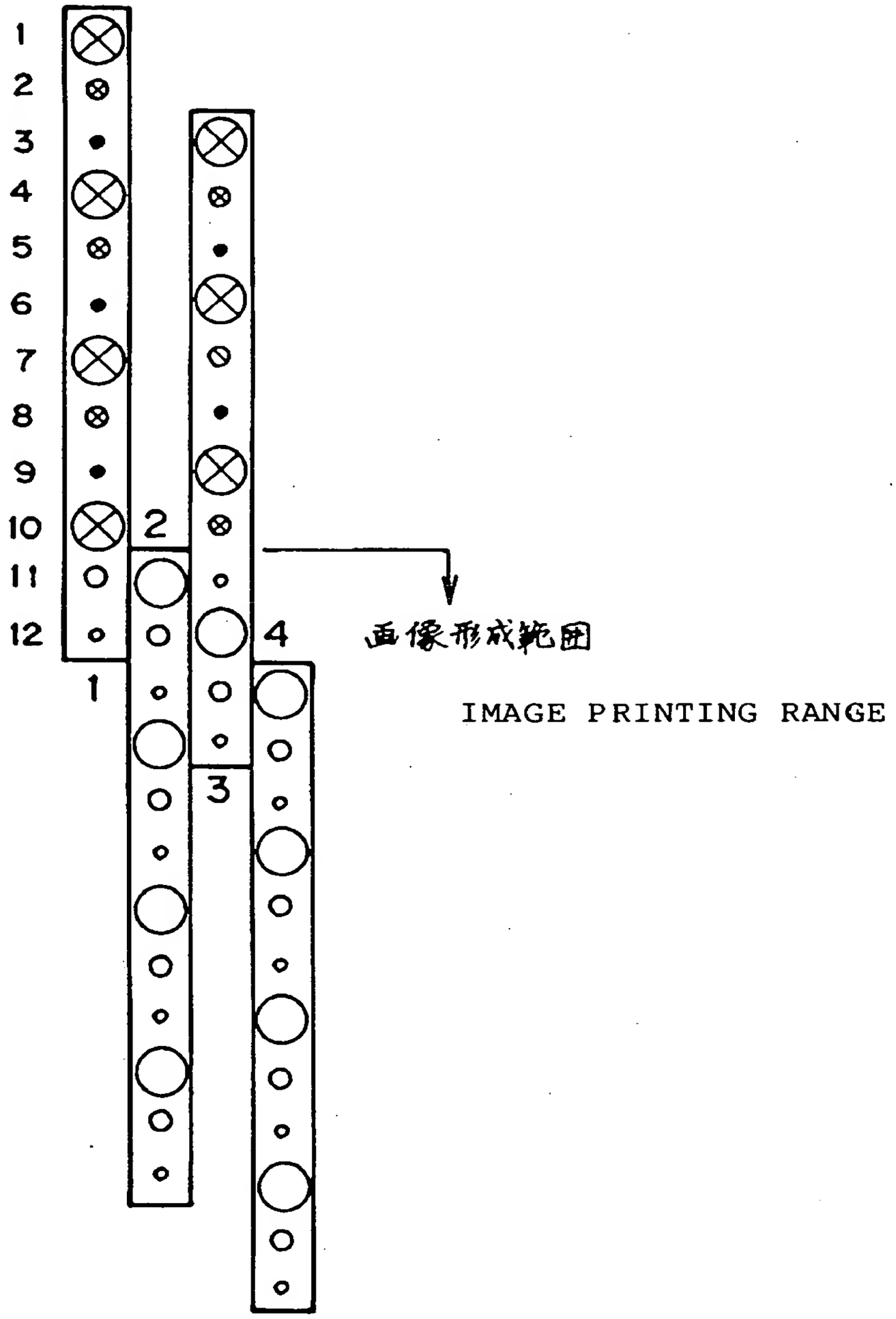


FIG. 20

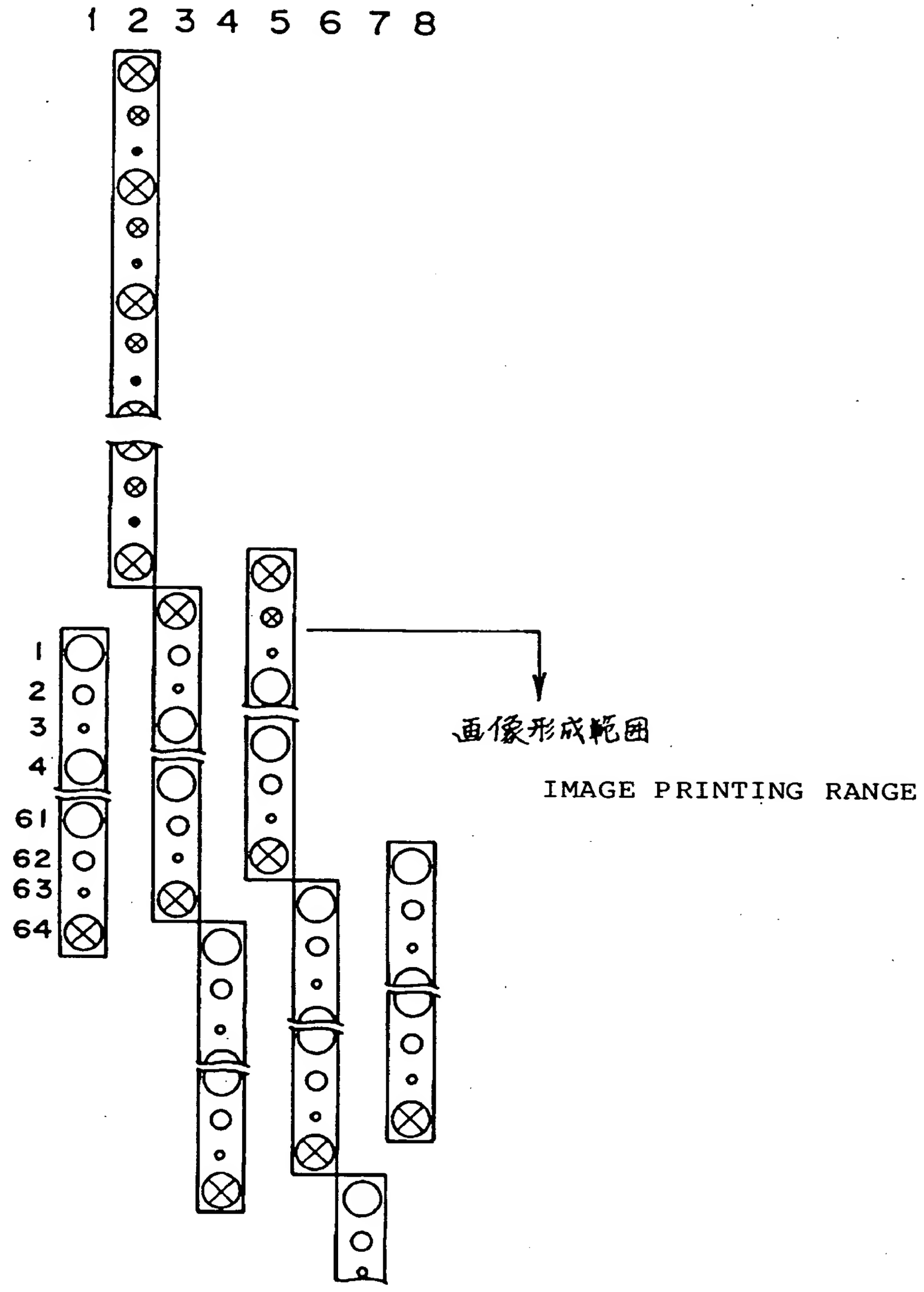
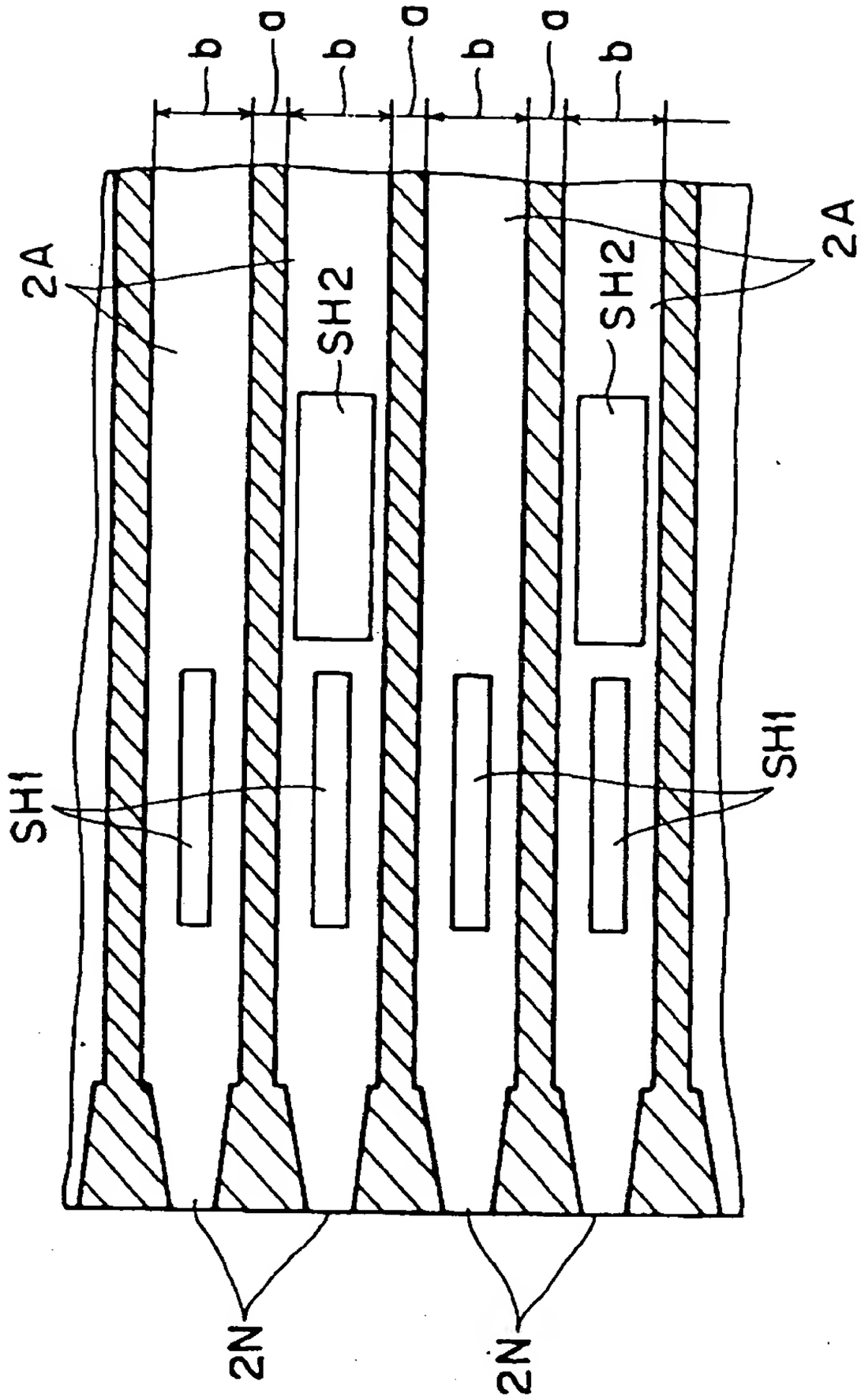
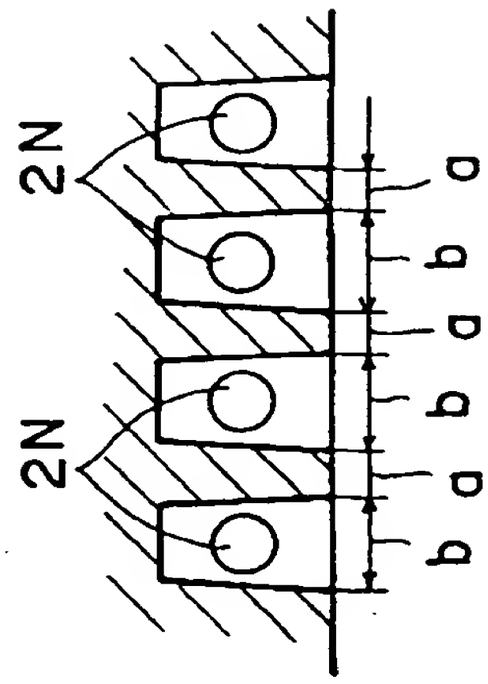


FIG. 21



(A)



(B)

Fig. 22

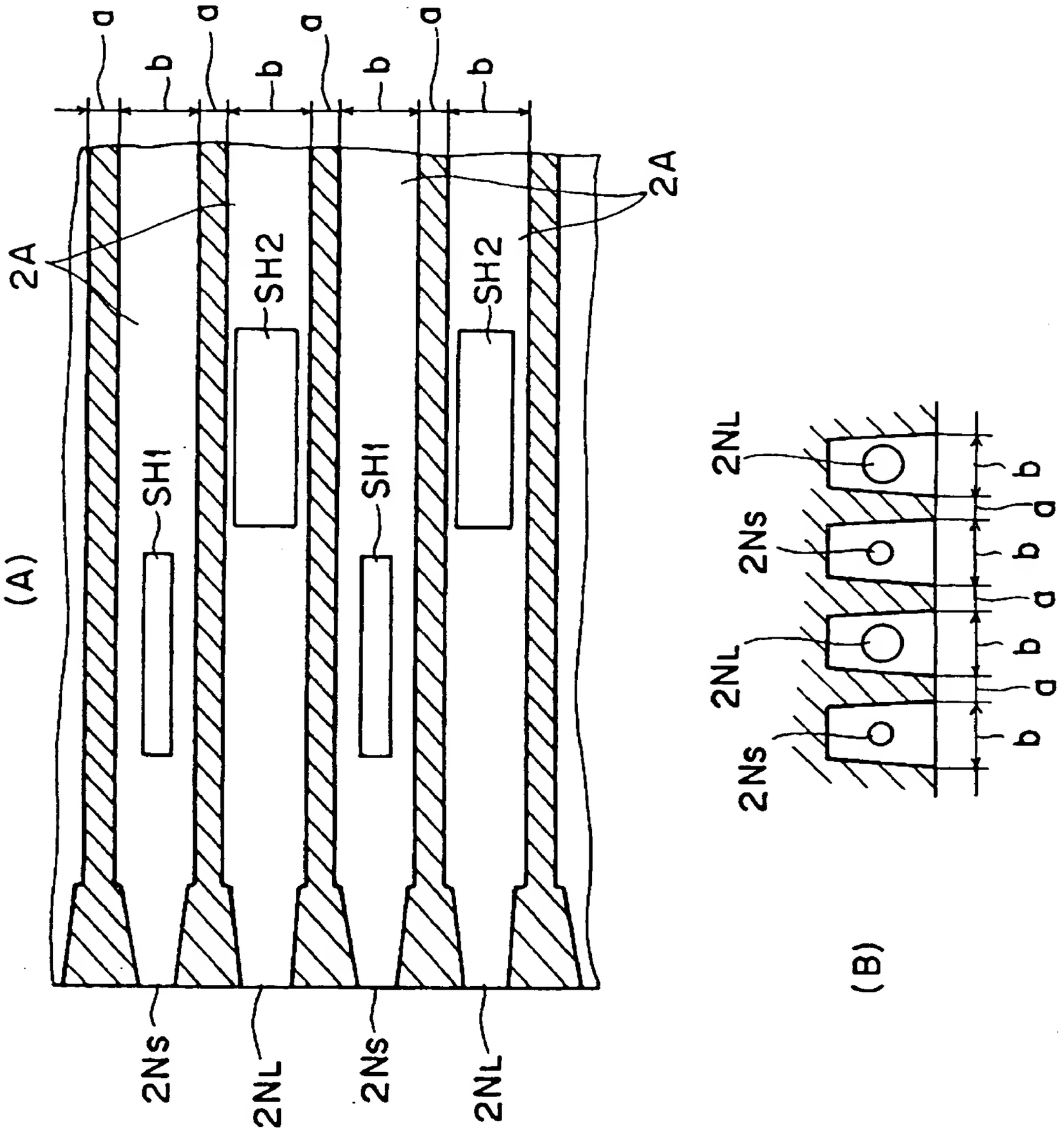


Fig. 23

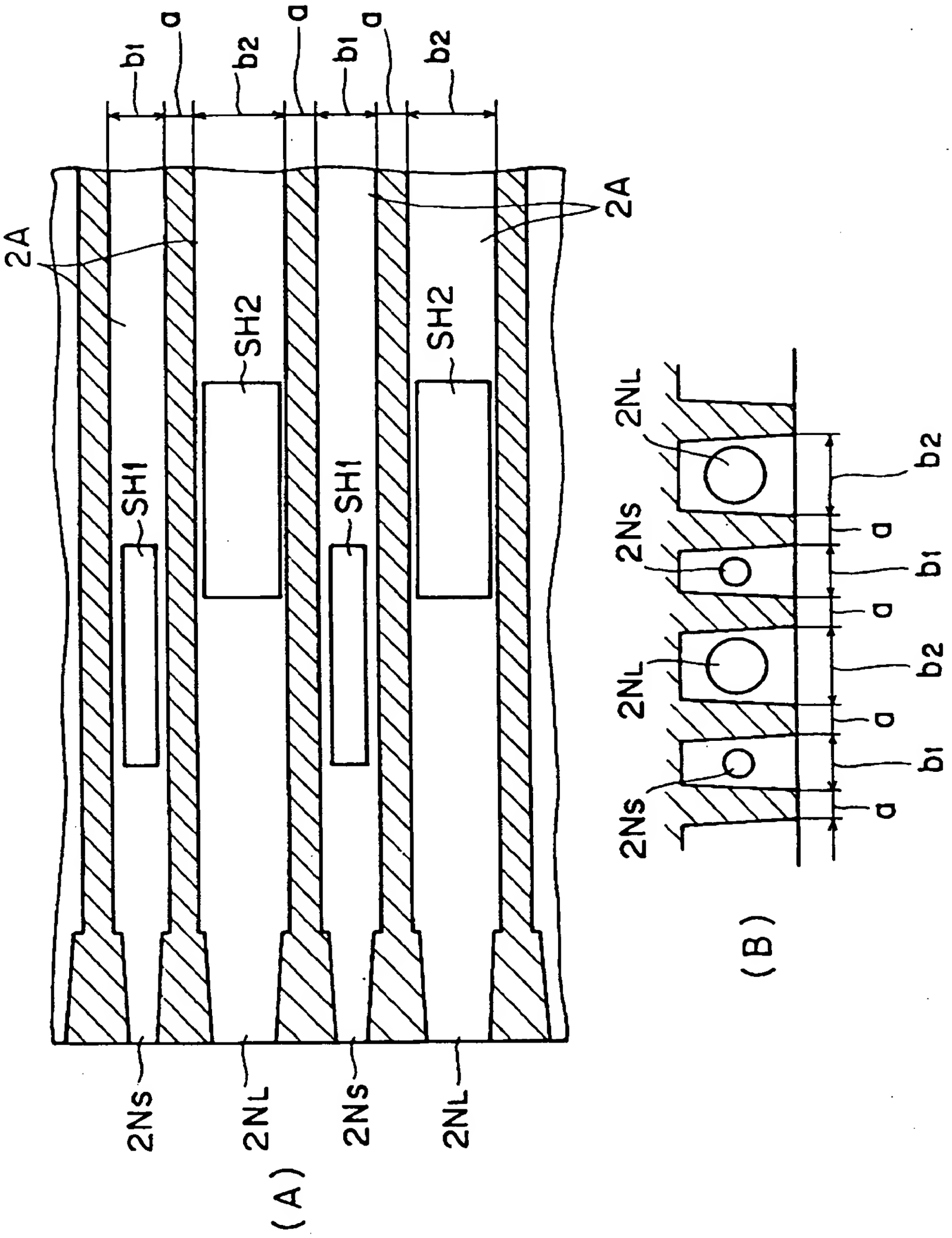
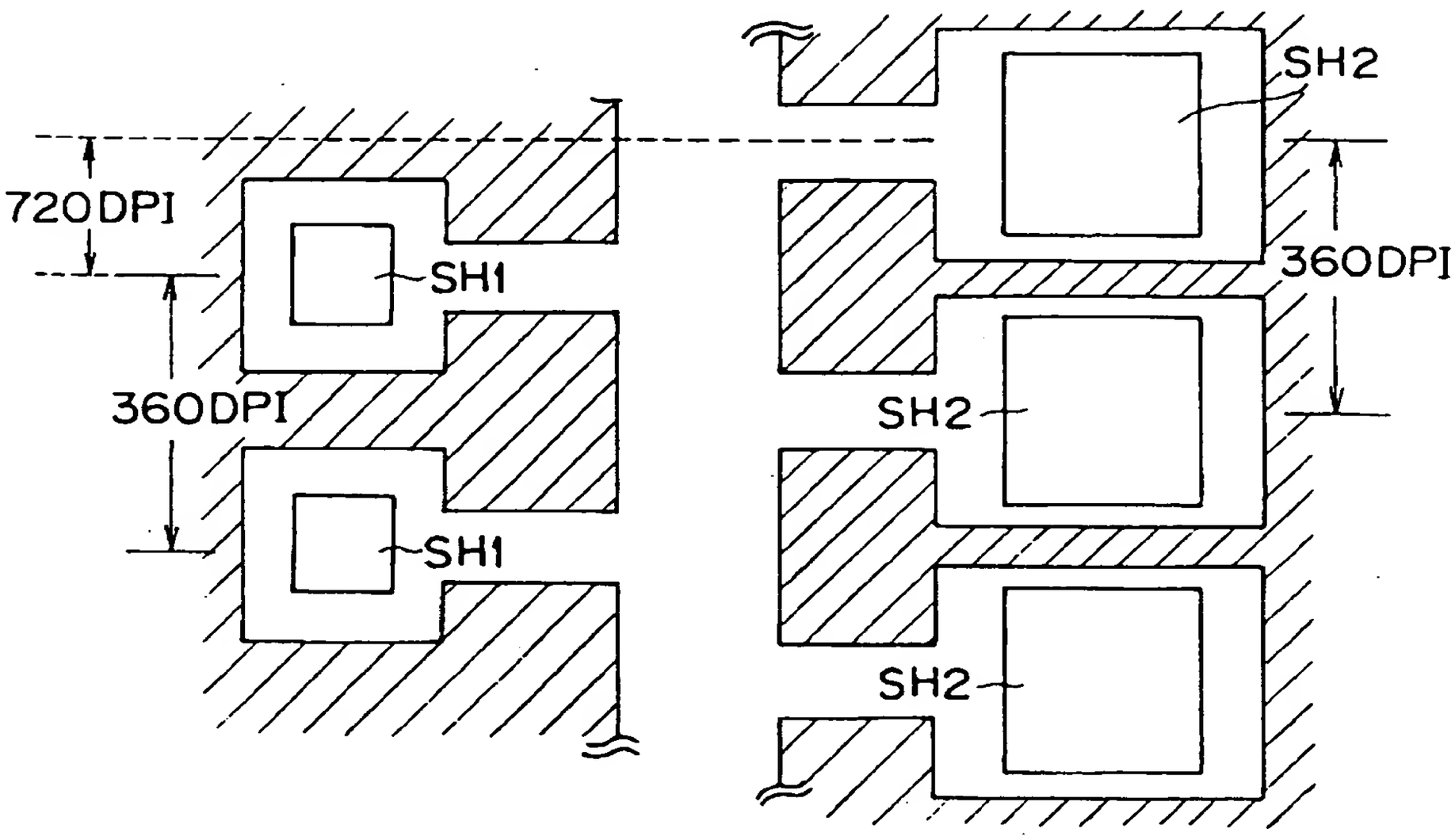

b1
d
b2
d
b1
d
b2
2A
2A
SH2
SH2
SH1
SH1
2Ns
2NL
2Ns
2NL
(A)
2NL
2Ns
2NL
2Ns
b2
d
d
b1
d
b2
d
b1
(B)

Fig. 24

(A)



(B)

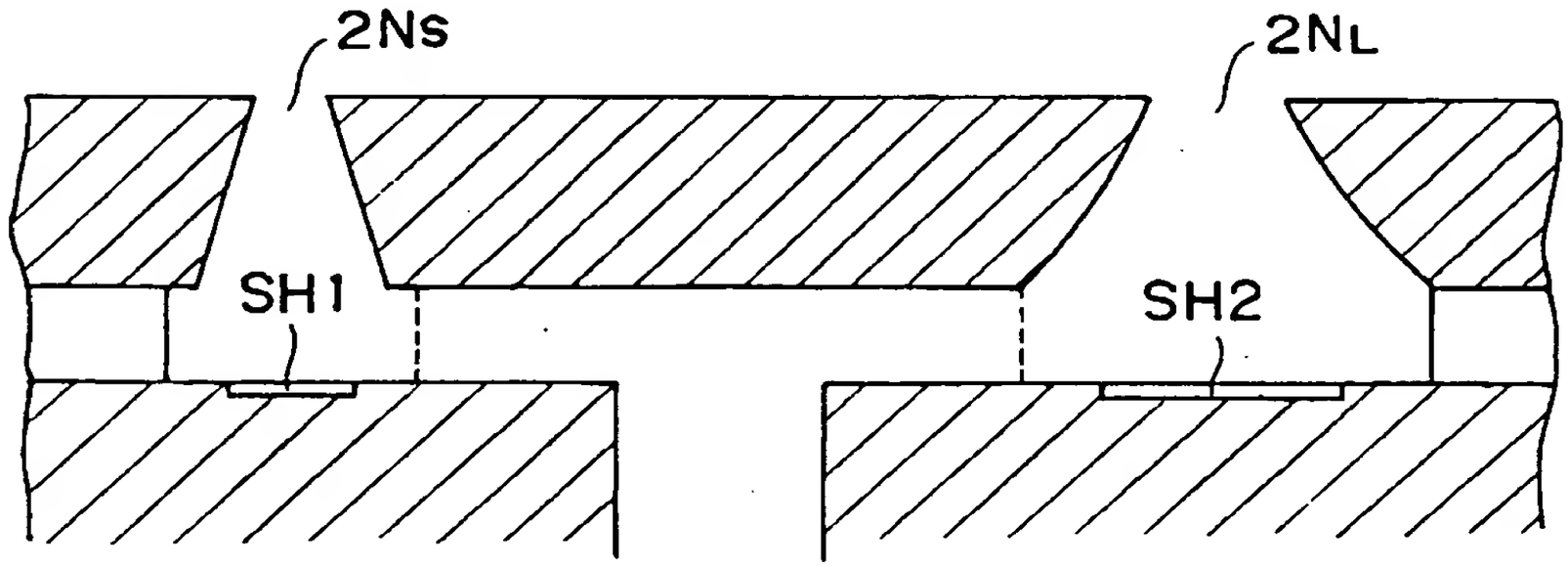


Fig. 25

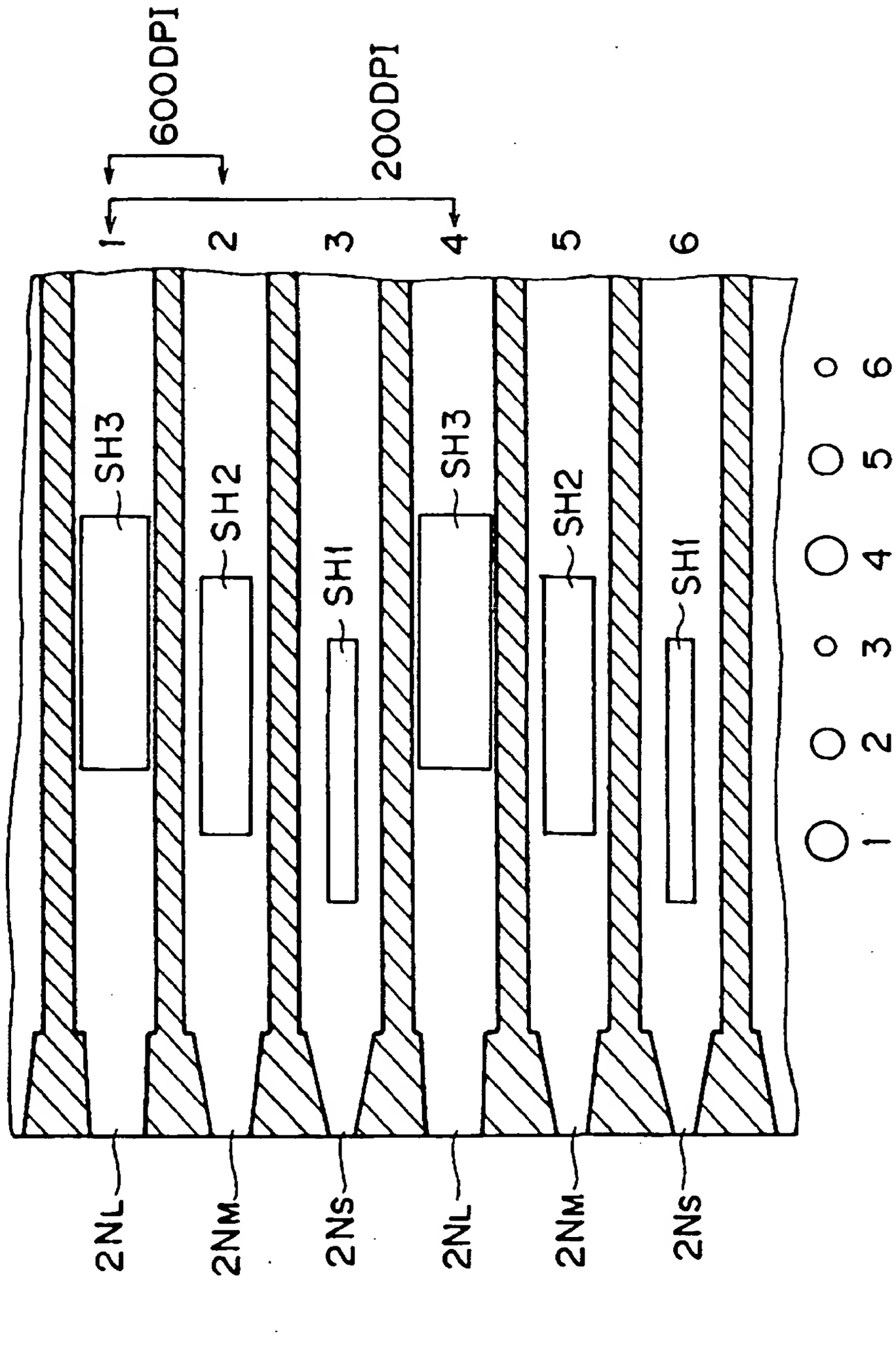
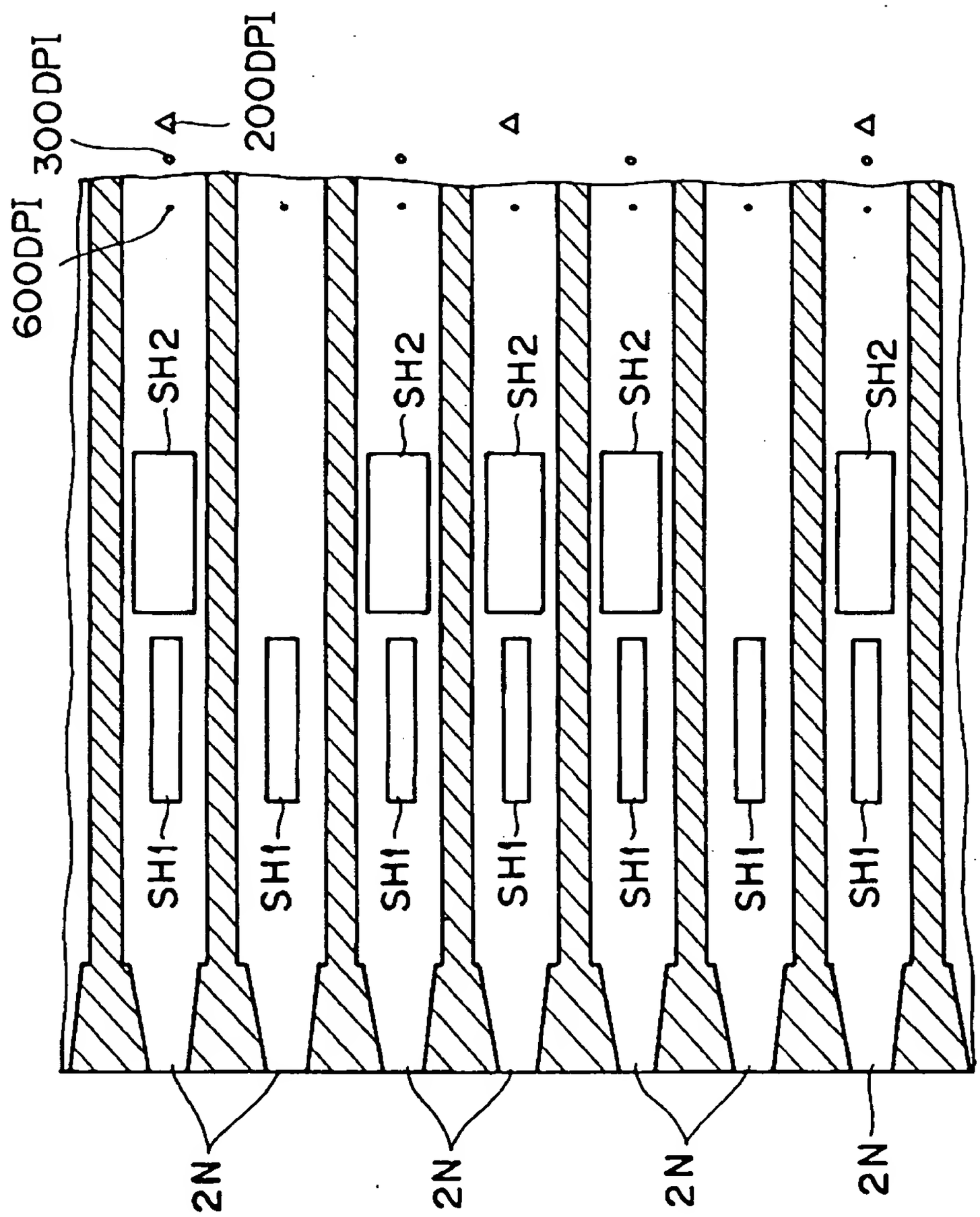

600DPI
200DPI
1
2
3
4
5
6
SH3
SH2
SH1
SH3
SH2
SH1
2NL
2NM
2Ns
2NL
2NM
2Ns
1 2 3 4 5 6

Fig.26



[Document Name] Correction Data Ex Offico

[Document Corrected] Patent Application

<Information Acknowledged · Information Added>

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1. Date of Change August 30, 1990

[Reason for Change]New Registration

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[DOCUMENT NAME] ABSTRACT

[Abstract]

[Object]

In an ink-jet apparatus using an ink-jet head having a plurality of heaters for one ink ejection opening, printing can be performed in various printing modes by using the fact that an ink ejecting amount from each ejection opening can be varied.

[Construction]

In each ejection opening 2N in an ink-jet head, an ejecting amount mode can be set per ejection opening at three stages by combining the presence or absence of driving of heaters SH1 and SH2. Furthermore, an ejection opening density can be selected from 720 DPI, 360 DPI and 240 DPI. Moreover, a high density mode, a smoothing mode, a multi-value print mode and a vertical registration mode can be set.

[Figure Selected]

Fig. 4

12.12.19

整理番号　２８３９１０６　　発送番号　３６３８７５
発送日　平成１２年１２月１５日　　１／　２

拒絶理由通知書

特許出願の番号　平成　６年　特許願　第３４０２６８号
起案日　平成１２年１２月１１日
特許庁審査官　桐畑　幸▲廣▼　９６０６　２Ｐ００
特許出願人代理人　谷　義一　（外　１名）様
適用条文　第２９条第２項

この出願は、次の理由によって拒絶をすべきものである。これについて意見があれば、この通知書の発送の日から６０日以内に意見書を提出して下さい。

理　由

本願の下記の請求項に係る発明は、下記引用例に記載された発明に基づいて、当業者が容易に発明をすることができたものであるから、特許法第２９条第２項の規定により特許を受けることができない。

記

・請求項　１～３
・引用例　１．特公昭６２－４８５８５号公報（公開－55－132259）
　　２．特開平３－２３４５３５号公報
・備考
　上記引用例１には、複数のヒータへの印加タイミングのずれを制御することにより、階調印字を行うインクジェット記録装置が記載されている。
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先行技術文献調査結果の記録

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(Translation)

Case No.: 2839106 Mailing Number: 363875
Mailing Date: December 15, 2000

OFFICIAL NOTICE OF REJECTION

Patent Application No. 340,268/1994

Date of Draft: December 11, 2000

Examiner, The Patent Office: Y. Kirihata 9606 2P00

Agent for Applicant: Yoshikazu Tani, Esq. (and one other)

Applied Provision(s): Section 29, Paragraph 2

The present application is rejected for the following reasons. The applicant may present an argument, if any, within 60 days from the mailing date of this Official Notice.

REASONS

The invention(s) of the present application as claimed in claim(s) set forth below could have been obvious to one skilled in the art, to which the invention(s) pertain(s), on the basis of the publication(s) as indicated below as distributed in Japan or foreign countries prior to the filing date of the present application. Therefore, the present invention(s) is(are) unpatentable under the provision of Section 29, Paragraph 2 of the Patent Law.

Note

Claims 1 to 3

References:

1. Japanese Patent Application Publication No. Sho 62-48585
2. Japanese Patent Application Laid-open No. Hei 3-234535

Remark:

Reference 1 discloses an ink-jet printing apparatus which performs a gradation printing by controlling a time lag of an applying timing to a plurality of heaters.

Reference 2 discloses that the art of controlling the amount of ink ejection can be applied not only to the gradation printing, but also to stabilization of the amount of ink ejection. Thus, one skilled in the art to reach the present invention from the above disclosure by using the invention of reference 1 to stabilize the amount of ink ejection. Moreover, the advantageous effect is of mere level that could have been expected.

Record of Search Results of Prior Art Literature

Technical Field Searched:

IPC 7th edition B41J 2/05, B41J 2/205

This record of search results of prior art literature does not constitute reason for rejection.

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Group Art unit: 2853

Examiner: S. Johnson, Jr.

Applicants	:	**Noribumi KOITABASHI et al.**	)
Application No.:		**08/579,241**	) TRANSLATION OF PRIORITY DOCUMENTS DECLARATION IN SUPPORT THEREOF
Filed	:	**December 28, 1995**	)
For	:	**INK-JET APPARATUS EMPLOYING INK-JET HEAD HAVING A PLURALITY OF INK EJECTION HEATERS CORRESPONDING TO EACH INK EJECTION OPENING**	)

Assistant Commissioner for Patents
Washington, D.C. 20231

Sir:

I, Atsuko SEKIGUCHI, of Tani & Abe Patent Office, No. 6-20, Akasaka 2-chome, Minato-ku, Tokyo 107-0052, Japan, declare that:

1. I know well both the Japanese and English languages.

2. I translated Japanese Patent Application No. 340268/1994 of December 29, 1994 from the Japanese language to the English language, a copy of the translation being attached hereto.

3. The attached English translation of the Japanese application identified in paragraph 2 above is a true and correct translation to the best of my knowledge and belief.

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code, and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

Signed this July 17, 2000

Atsuko Sekiguchi

Atsuko SEKIGUCHI

PATENT OFFICE
JAPANESE GOVERNMENT

This is to certify that the annexed is a true copy of the following application as filed with this Office.

Date of Application: December 29, 1994

Application Number: Japanese Patent Application No. 340268/1994

Applicant(s): CANON KABUSHIKI KAISHA

January 26, 1996

Commissioner,
Patent Office Yuji KIYOKAWA

Certificate No. 3085361/1995

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340268/1994

Applicant's Case Number: 2839106 (1/2)

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To: Commissioner, the Patent Office

(International Patent Classification) B41J 2/01

(Title of the Invention)

AN INK-JET APPARATUS

(Number of claims) 3

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Applicant's Case Number: 2839106 (2/2)

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Specification	1 copy
Formal Drawings	1 copy
Abstract	1 copy
General Authorization Number	9004548

(Necessity of Proof) Yes

[DOCUMENT NAME] SPECIFICATION

[TITLE OF THE INVENTION]

An Ink-Jet Apparatus

[SCOPE OF CLAIM FOR A PATENT]

[Claim 1]

An ink-jet apparatus in which an ink-jet head having a plurality of heaters for one ink ejection opening is used to eject ink therefrom to a medium, the ink-jet apparatus comprising:

driving means for applying pulses to the plurality of heaters so as to allow the ink to bubble, thereby ejecting the ink through one ink ejection opening, the driving means being capable of shifting bubbling timings in the plurality of heaters on the basis of information relating to an ink temperature of the ink-jet head.

[Claim 2]

An ink-jet apparatus as claimed in claim 1, wherein the plurality of heaters are identical in position relative to one ejection opening, size and heating characteristics with respect to each other.

[Claim 3]

An ink-jet apparatus as claimed in claim 1, wherein the plurality of heaters are different in position relative to one ejection opening, size and heating characteristics from each other.

[DETAILED DESCRIPTION OF THE INVENTION]

[0001]

[Field of Industrial Utilization]

The present invention relates to an ink-jet apparatus. More specifically, the invention relates to an ink-jet apparatus using an ink-jet head having a plurality of ejecting heaters on an ink path corresponding to each of ink ejection openings.

[0002]

[Prior Art]

An ink-jet apparatus has been mainly known as a printing apparatus in printers, copy machines and the like. Among various ink-jet apparatus, there has become recently widespread an ink-jet printing apparatus of the type in which thermal energy is used as energy for ink ejection, for ejecting ink with bubbles generated by the thermal energy. In addition, as other applications of this type of ink-jet printing apparatus has become known in recent years an ink-jet textile printing apparatus for printing a given pattern, a picture, a synthesized image or the like on cloth.

[0003]

An ink-jet head for use in such an ink-jet printing apparatus as described above has an electrothermal transducer element (hereinafter also referred to as "a heater") as a source for generating

thermal energy. In most cases, the ink-jet head is provided with one heater corresponding to one ejection opening. In contrast, there has been known an ink-jet head using a plurality of heaters in each of ink ejection openings for the reasons discussed below.

[0004]

First, it has been known to alternately or selectively drive a plurality of heaters for the purpose of extension of the life of the ink-jet head. Second, a plurality of heaters are used for widening the range of variations in ink ejection amount, wherein the ink ejection amount is varied by selecting heaters to be driven or the number of heaters to be driven.

[0005]

In the latter case, in a more specific structure, a plurality of heaters are arranged along an ink ejecting direction on an ink path communicating with the ejection opening in the ink-jet head, so that a distance between the ejection opening and the heaters to be driven is varied by selecting the heaters to be driven (namely, the heaters to be made to generate heat) or the number of heaters to be driven, thus varying the ejection amount of the ink.

[0006]

Another structure of the ink-jet head has been known in which a plurality of heaters different in

surface area are arranged on an ink path, to make an ink ejection amount variable by varying the heaters to be driven or the number of heaters to be driven.

[0007]

In ink-jet heads of the type in which the ink is ejected using the above-described heater, when a head temperature or, more particularly, an ink temperature is varied, the ink ejection amount can be varied even if the variation range is not so significant. Therefore, when the head temperature is elevated according to the progress of printing operation, a problem of variations in image quality can be caused due to variations in ejection amount. In order to solve the above-described problem, the applicant of the present invention has already proposed the structure for stabilizing the ejection amount regardless of the variations in head temperature, as disclosed in Japanese Patent Application Laid-open No. 31905/1993. Here, two sequential pulses are applied to the heater in each ink ejection for controlling a pulse width or the like of a preceding one out of the two pulses (hereinafter also referred to as "pre-heat control"), thereby controlling the head temperature so as to stabilize the ejection amount.

[0008]

[Problems to be Solved by the Invention]

In the structure in which the ejection amount can be varied in multiple modes by selecting the heaters to be driven in the above-described ink-jet head by using the plurality of ejecting heaters, it is, of course, desirable to stably maintain each of set ejection amounts.

[0009]

Japanese Patent Application Laid-open No. 132259/1980 discloses representation of gradation in the above-described structure in which the plurality of heaters are used. However, such a structure cannot stabilize the ejecting amount.

[0010]

The present invention has been accomplished in an attempt to solve the above-described problems. Therefore, an object of the present invention is to provide an ink-jet apparatus in which an ink-jet head having a plurality of heaters for one ejection opening is used to stabilize an ejection amount with a relatively simple structure.

[0011]

[Means for Solving the Problems]

According to the present invention, an ink-jet apparatus in which an ink-jet head having a plurality of heaters for one ink ejection opening is used to

eject ink therefrom to a medium, comprises driving means for applying pulses to the plurality of heaters so as to allow the ink to bubble, thereby ejecting the ink through one ink ejection opening, the driving means being capable of shifting bubbling timings in the plurality of heaters on the basis of information relating to an ink temperature of the ink-jet head.

[0012]

[Function]

With the above-described configuration, the ejection amount is reduced in comparison with the case where pulses are simultaneously applied to all of the heaters by shifting pulse applying timings of the plurality of heaters in such a manner that the reduced amount becomes greater as the shifted timing becomes longer. In this configuration, the shifted timing is varied based on information relating to an ink temperature of the ink-jet head. Therefore, even if the ejection amount is to be increased according to an ink temperature rise, an increase in ejection amount can be suppressed by lengthening the shifted timing, thereby stabilizing the ejection amount.

[0013]

[Preferred Embodiments]

Preferred embodiments according to the present invention will be discussed hereinafter in detail with reference to the accompanying drawings.

[0014]

Fig. 1 is a perspective view showing a printer as an ink-jet printing apparatus according to the present invention.

[0015]

In Fig. 1, reference numeral 101 denotes a printer, reference numeral 102 denotes an operation panel provided at the upper front portion of a housing of the printer 101, reference numeral 103 denotes a sheet feeding cassette to be inserted into an opening at the front face of the housing, reference numeral 104 denotes a sheet (recording medium) to be fed from the sheet feeding cassette 103, and reference numeral 105 denotes a discharged sheet tray for holding sheets discharged via a sheet feeding path inside the printer 101. Reference numeral 106 denotes a main body cover in an L-shaped cross section. The main body cover 106 is designed for covering an opening 107 formed at the right front portion of the housing, and is pivotally mounted at the inner end of the opening 107 by means of a hinge 108. In addition, within the housing, a carriage 110 supported by a guide or the like (not shown) is arranged. The carriage 110 is provided in such a manner as to movably reciprocate in a width direction of the sheet to be fed on the sheet feeding path (hereinafter also referred to as "a primary scanning direction").

[0016]

The carriage 110 in the present embodiment generally comprises a stage 110a to be held horizontally by the guide or the like, an opening (not shown) for accommodating ink-jet heads at a rear portion on the stage 110a, a cartridge garage 110b for receiving ink-jet heads 3Y, 3M, 3C and 3Bk which are detachably loaded on the stage 110a in front of the opening, and a cartridge holder 110c opened and closed relative to the garage 110b so as to prevent any detachment of a cartridge received within the garage 110b.

[0017]

The stage 110a is slidably supported at the rear end thereof by means of a guide, and further, slidably engages with a not-shown guide plate at the lower portion of the front end thereof. The guide plate may serve as a sheet holding member for preventing the sheet fed via the sheet feeding path from floating, or may have a function of lifting up the stage relative to the guide in a cantilever fashion according to the thickness of the sheet.

[0018]

In the opening of the stage 110a is loaded the ink-jet head (not shown) with ink ejecting openings directed downward.

[0019]

The cartridge garage 110b is provided with a through opening extending in a lengthwise direction, for simultaneously receiving the four ink cartridges 3Y, 3M, 3C and 3Bk. On the both sides of the outer surfaces of the cartridge garage 110b are formed engaged recesses to be engaged with engaging claws of the cartridge holder 110c.

[0020]

At the front end of the stage 110a, the cartridge holder 10c is pivotally mounted via a hinge 116. The dimension from the front end of the garage 110b to the hinge 116 is determined in consideration of a projecting dimension from the cartridges 3Y, 3M, 3C and 3Bk from the front end of the garage 110b when the cartridges 3Y, 3M, 3C and 3Bk are received inside the garage 110b. The cartridge holder 110c is formed into a substantially rectangular plate. On the cartridge holder 110c, a pair of engaging claws 110e project in a direction perpendicular to the plate surface on both sides of the upper portion away from the lower portion fixed via the hinge 116, and engage with engaged recesses 110d formed at the garage 110b when the holder 110c is closed. An insertion hole 120, to which the respective handles of the cartridges 3Y, 3M, 3C and 3Bk are inserted, is formed in the plate of the holder 110c. The insertion hole 120 is formed into a

corresponding shape at a corresponding position in a corresponding size to the handles.

[0021]

Fig. 2 is a block diagram illustrating an example of the arrangement of a control system in the ink-jet printing apparatus.

[0022]

Here, reference numeral 200 denotes a controller constituting a main control unit, which includes a CPU 201 in a form of, for example, a microcomputer for executing various modes, described later, a ROM 203 storing therein fixed data such as programs, tables, voltage values of a heat pulse and pulse widths, and a RAM 205 provided with a region for developing image data and a region for working. Reference numeral 210 denotes a host system (or a reader unit for reading an image) serving as a supply source of the image data. The image data, other commands, status signals and the like are transmitted to or received from the controller via an interface (I/F) 212.

[0023]

The operation panel 102 is provided with a switch group which receives commands input by an operator and includes a mode selector switch 220 for selecting various modes, a power source switch 222, a print switch 224 for designating starting of printing, an ejection recovering switch 226 for designating

initiation of ejection recovering processes, and the like, as described later. Reference numeral 230 denotes a sensor group which detects the condition of the apparatus and includes a sensor 232 for detecting positions of the carriage 110 (see Fig. 1) such as a home position and a start position, and a sensor 234 to be used for detecting a pump position including a leaf switch.

[0024]

Reference numeral 240 denotes a head driver for driving an electrothermal transducer element of the ink-jet head in accordance with printing data and the like. A part of the head driver also may be used for driving temperature heaters 30A and 30B. Furthermore, temperature detection values are input to the controller 200 from temperature sensors 20A and 20B. Reference numeral 250 denotes a primary scanning motor for shifting the carriage 110 in a primary scanning direction, and reference numeral 252 denotes a driver for the motor 250. Reference numeral 260 denotes an auxiliary scanning motor which is used for feeding the sheet 104 as the recording medium (see Fig. 1).

[0025]

The above-mentioned ink-jet printing apparatus has the ink-jet head cartridges 2C, 2M, 2Y and 2Bk for inks of four colors, i.e., cyan, magenta, yellow and black, respectively.

[0026]

Fig. 3 is a cross-sectional view showing an ink tank cartridge 3 and an ink-jet head 2 to be used in the above-mentioned ink-jet printing apparatus in a connected state.

[0027]

The ink tank cartridge 3 used in the present embodiment includes two chambers of a vacuum generating member containing chamber 53 filled with ink absorbers 52, and an empty ink containing chamber 56. In the initial condition, ink is filled in both of these chambers. In association with ink ejection and the like in the ink-jet head 2, the ink in the ink containing chamber 56 is first consumed.

[0028]

The ink-jet head 2 has heaters (not shown in Fig. 3) for generating thermal energy to be used for ejection on a plurality of ink paths 2A corresponding to the ink ejection openings, for ejecting the ink supplied from the ink tank cartridge 3 via a connection pipe 4.

[0029]

(First Embodiment)

Figs. 4(a) and 4(b) are cross-sectional views showing two examples of ink-jet heads which can be used in a first embodiment according to the present invention.

[0030]

As shown in Figs. 4(a) and 4(b), two heaters SH1 and SH2 are arranged on each of ink paths 2A. The two heaters are identical in surface area to each other, and electrodes are wired (not shown) such that the heaters can be driven also independently of each other. At the tip end of the ink path 2A is opened an ejection opening 2N.

[0031]

The structures, which are provided in the predetermined number per ink path and each of which consists of the heaters, the ejection opening and the ink path, are arranged in the ink-jet head 2 in the density of 360 DPI. In the present embodiment, the area of the ejection opening and the area of the heater are the same in each ink path.

[0032]

Next, a description will be given of an ejection amount stabilizing control on the basis of the construction in the present embodiment illustrated in Figs. 1 to 4.

[0033]

Fig. 5 is a graph illustrating the environmental temperature dependency of an ejection amount Vd of the ink-jet head. As can be clear from Fig. 5, the higher the environmental temperature T_R, the greater the ejection amount. The environmental temperature

dependency illustrated in Fig. 5 becomes evident in the case where a pulse illustrated in Fig. 6(a) is applied to each of the two heaters SH1 and SH2 shown in Fig. 4: namely, in the case where the same pulse is simultaneously applied to the two heaters SH1 and SH2.

[0034]

In contrast, the present inventors have reached the present invention by utilizing a phenomenon that when two pulses with a shifted period, as illustrated in Fig. 2, are applied to the heaters SH1 and SH2, respectively, the relationship between the shifted period τ and the ejection amount is illustrated in Fig. 7: the ejection amount Vd becomes maximum when the shifted period τ is zero, and the ejection amount Vd is decreased at a greater value of the shifted period τ irrespectively of whether it is positive or negative.

[0035]

It is considered that this phenomenon is caused by the fact that a pressure in bubbling of the ink on the heater or a maximum bubbling volume is reduced according to a shifted timing. In the present embodiment, the ejection amount is controlled by combining the temperature dependency of the ejection amount with the shifted period of the two pulses, as described above.

[0036]

A specific example will be explained below.

[0037]

Fig. 8 illustrates a table for storing therein shifted periods for head temperatures; Fig. 9 is a graph illustrating a mode of ejection amount control based on the table; and Fig. 10 is a flowchart illustrating a sequence of ejection amount controls.

[0038]

As illustrated in Fig. 9, (1) when $Th \leqq T0$, namely, the head temperature is lower than or equal to a relatively low, predetermined temperature T0, the ejection amount control is performed by adjusting the temperature of the ink-jet head without using the shifted period so as to make the ejection amount constant. Such temperature adjustment may be omitted by setting T0 at a small value.

[0039]

Next, (2) when $T0 < Th \leqq TL$, namely, the head temperature is higher than T0 and lower than or equal to a predetermined temperature T1, an ejection amount is stabilized by the ejection amount control by a bubbling timing modulating method using the shifted period. Further, (3) when $TL < Th$, namely, the head temperature is higher than TL, the shifted period for the bubbling timing is fixed at the maximum value.

[0040]

In the ejection amount control under the condition (1), the head temperature T0 is set at 26 °C in the present invention. At this time, voltage waveforms to be applied to the two heaters are the same in size and timing as each other, as illustrated in Fig. 6(a), since no shifted period is used. Therefore, the ejection amount at this time becomes maximum.

[0041]

The control under the condition (2) is performed within the range of the head temperatures from T0 = 26 °C to TL = 53 °C. The shifted period is varied according to variations in head temperature based on the table illustrated in Fig. 8. More specifically, here, the shifted period τ is lengthened as the head temperature Th becomes higher. That is, the overall ejection amount is adjusted to be constant by lengthening a period delayed from the applying timing of the heater as a reference.

[0042]

Referring to Fig. 10 illustrating this sequence, in order to avoid any erroneous detection of the head temperature and more accurately detect the temperature, a temperature obtained by averaging past three temperatures (T(n-3), T(n-2), T(n-1)) and a newly detected temperature Tn (step S1) is used as Tn' =

(T(n-3) + T(n-2) + T(n-1) + Tn)/4 (step S2). In the next step, the value Th' and a currently measured head temperature Th = Tn are compared with each other (step S3), thereby obtaining Th - T(n-1) = ΔT.

1) In the case of $|\Delta T| < 1$ °C

Since the temperature variation is within ±1 °C and is within the range of one table range, the shifted period is not varied (step S5).

[0043]

2) In the case of $\Delta T \geqq 1$ °C

Since the temperature variation is shifted onto a higher temperature side, the table is lowered by one to lengthen the shifted period (step S6).

[0044]

3) In the case of $\Delta T \leqq -1$ °C

Since the temperature variation is shifted onto a lower temperature side, the table is increased by one to shorten the shifted period (step S4).

[0045]

The control is performed while varying the table in the above-described manner. A timing for varying the table by one during printing is set at 20 msec. The table may be varied any time during printing of one line. By this, it becomes possible to reduce or prevent any variation in density due to abrupt variations in temperature caused by high-duty printing.

[0046]

In the ejection amount control in the present embodiment, the shifted period is set in a unified way based on the head temperature, thus making it possible to maintain the ejection amount substantially constant with only slight fluctuations with respect to a target ejection amount Vd_0.

[0047]

The ejection amount control within the temperature adjusting range shown in Fig. 9 is performed by applying such a short pulse as not to cause bubbling to a heater not used. Alternatively, a sub-heater may be used.

[0048]

(Second Embodiment)

Fig. 11 illustrates a shifted period table in a second embodiment according to the present invention.

[0049]

While the control for lengthening the shifted period is performed by producing delay with respect to the predetermined timing in the first embodiment set forth above, the ejection amount control is performed by advancing the shifted period in the present embodiment, as illustrated in Fig. 11. The pulse waveforms in the first embodiment and the present embodiment are the same in terms of the shifted period relative to the head temperature, and therefore, the

ejection amounts become the same as each other. However, an absolute applying timing in the present embodiment becomes earlier than that in the first embodiment.

[0050]

(Third Embodiment)

In the foregoing two embodiments, the shifted period $\tau=0$ is taken as the starting point of the shifted period in the table. However, as illustrated in Fig. 7, since the ejection amount is not significantly varied in the vicinity of the shifted period being 0, it is not possible to stably control the ejection amount within this range unless the shifted period is greatly varied with respect to certain head temperature variations. Therefore, an initial shifted period is previously set at a predetermined value other than zero, as illustrated in Fig. 12, thereby making it possible to make the variation width of the shifted period at each stage constant in the overall control range. While the control range of the ejection amount becomes slightly narrower in this case, no significant problem may be arisen.

[0051]

(Fourth Embodiment)

In the present embodiment is illustrated an example of control for an ink-jet head having two heaters of different sizes disposed in one ink path.

[0052]

Fig. 13 shows the ink-jet head in the present embodiment. Corresponding to one ejection opening, two heaters SH1 and SH2 respectively having large and small sizes are provided. The heaters are equal in longitudinal length to each other. When an electric pulse in a width of 5 μsec. at a voltage of 18V is applied to each of the heaters in the longitudinal direction, 15 pl/dot of ink droplets are ejected by the small heater and 25 pl/dot of ink droplets are ejected by the large heater. Also, when both of the small and large heaters SH1 and SH2 are driven simultaneously, the ejection amount becomes 40 pl. Hereinafter, modes of these ejection amounts are referred to as a small ejection amount mode, a medium ejection amount mode and a large ejection amount mode, respectively.

[0053]

When ink droplets are ejected in each of the ejection amount modes, the ejection amount is increased according to an increase in temperature of the ink-jet head, as illustrated in Fig. 14.

Consequently, even in this case, if the ink-jet head temperature is varied according to the environmental variations, self-temperature rises or the like to thus cause variations in ejection amount in each of the ejection amount modes, the density and hue of an image may be varied or the density may be fluctuated, degrading an image quality.

[0054]

On the other hand, if the bubbling timing is shifted by shifting applying pulse timings between the large heater and the small heater, the ejection amount becomes maximum at the same applying timing while it becomes smaller with the timing shifted forward or backward, as illustrated in Fig. 15. This is basically the same as the foregoing embodiments. However, within the range of ±10 μsec. relative to the simultaneous applying timing, if the bubbling timing of the small heater is made relatively earlier, the ejection amount becomes comparable with that when only the small heater is driven. Conversely, when the bubbling timing of the large heater is made relatively earlier, the ejection amount becomes comparable with that when only the large heater is driven.

[0055]

Using these results, a description will be given below of an example of the control for stabilizing the ejection amount in the case where the head temperature

is varied in the large ejection amount mode of 40 pl/dot and the medium ejection amount mode of 25 pl/dot, respectively.

[0056]

In the above description, when the pulse applying timings are the same, the bubbling timings also are the same. However, when the sizes of the heaters are different, as in the present example, it is not always possible to make the bubbling timing the same by making the pulse applying timings the same in a strict sense.

[0057]

(Large Ejection Amount Mode)

At first, in the case of the large ejection amount mode, i.e., in the ejection amount of 40 pl/dot, the temperature is adjusted by the sub-heater at the ink-jet head temperatures up to 26 °C and the large heater and the small heater are driven at the same timing, like the first embodiment.

[0058]

At the ink-jet head temperatures higher than or equal to 26 °C, the applying timing of the large heater is greatly delayed according to an increase in ink-jet head temperature, as illustrated in a table of Fig. 6(a), thereby stabilizing the ejection amount at 40 pl. The range of the shifted period illustrated in Fig. 16(a) is indicated by (A) in Fig. 15.

[0059]

(Medium Ejection Amount Mode)

Next, a description will be given of the medium ejection amount mode of 25 pl/dot.

[0060]

Similarly to the large ejection amount mode, when the head temperature Th is lower than 26 °C, the temperature of ink-jet head is adjusted, and the pulse applying timing of the large heater is delayed by 3.5 μsec. relative to the pulse applying timing of the small heater.

[0061]

On the other hand, when the head temperature Th is higher than or equal to 26 °C, the applying timing of the large heater is further delayed with an increased head temperature, as illustrated in Fig. 16(b), thereby stabilizing the ejection amount at 25 pl. The range of the shifted period illustrated in Fig. 16(b) is indicated by (B) in Fig. 15.

[0062]

While the ejection amount is maintained at 25 pl by the head temperature adjustment in the range in which the head temperature is lower than 26 °C in the above-mentioned medium ejection mode, the delay of the applying timing of the large heater may be controlled to be reduced according to an increase in temperature, namely, it may be controlled to reduce a shift in

applying timing between the small heater and the large heater. In this case, since the ejection amount cannot be further controlled after the shift in applying timing becomes zero, the temperature need be adjusted. However, the temperature at that timing substantially becomes lower than or equal to 0 °C, thus giving not so significant an influence. The range of the shifted timing is indicated by (B)' in Fig. 15.

[0063]

In the present embodiment, the ejection amount is controlled by delaying the pulse applying timing of the large heater relative to the pulse applying timing of the small heater. Here, what is basically important is the relative shift of the pulse applying timings. Therefore, the ejection amount may be controlled by delaying the pulse applying timing of the small heater relative to the pulse applying timing of the large heater.

[0064]

(Fifth Embodiment)

The present embodiment basically has the large ejection amount mode of 40 pl and the medium ejection amount mode of 25 pl, similarly to the foregoing fourth embodiment. In the medium ejection amount mode, control similar to that in the fourth embodiment is performed: namely, the driving timing of the large

heater is delayed while the driving timing of the small heater is fixed. In contrast, in the large ejection amount mode, the driving timing of the large heater is fixed while the driving timing of the small heater is delayed. Control tables are illustrated in Figs. 17(a) and 17(b).

[0065]

The range of the shifted timing in the large ejection amount mode is indicated by (C) illustrated in Fig. 15.

[0066]

While the heads having the plurality of heaters of different sizes are arranged in parallel relative to the ejection opening in the ink path in the above-described fourth and fifth embodiments, similar control can be performed even in the case where heaters are vertically aligned, as shown in Fig. 18. Alternatively, similar control is performed in heads of a type in which ink is ejected in a direction perpendicular to a heater surface, as shown in Fig. 19.

[0067]

In the above-described embodiments, the head temperatures or environmental temperatures are detected, and then, the ejection amount is stably controlled on the basis of the detected temperatures. However, the information relating to the ink temperature is not limited to that in the above-

described embodiments. The temperature may be estimated on the basis of calculation of a driving amount such as the number of times of ejection.

[0068]

Further, while the description has been given of the case where the two heaters are provided in one ink path in the above-described embodiments, the application of the present invention should not be limited to the construction. It is needless to say that the present invention is applicable to, for example, the case where three or more heaters are provided in the ink path.

[0069]

(Others)

According to the present invention, particularly among the ink-jet recording systems, the excellent effects can be produced in the recording head or apparatus of the system provided with the means for generating thermal energy (e.g., an electrothermal transducer, a laser beam or the like) as energy utilized for performing the ink ejection so as to induce the ink state variation caused by the thermal energy, thus achieving high density and high fineness of recording.

[0070]

It is preferable that the basic principle disclosed in, e.g., U.S. Patent No. 4,723,129 or

4,740,796 should be used for the typical configuration and principle of the above-described apparatus. This system can be applicable to either an on-demand type or a continuous type. Particularly, the on-demand type is effective because at least one drive signal for rapidly increasing a temperature in excess of a film boiling point in response to recording information is applied to the electrothermal transducer arranged in a manner corresponding to a sheet holding liquid (ink) thereon or a liquid path, thereby generating thermal energy in the electrothermal transducer so as to generate film boiling at a heat acting surface of the recording head, resulting in formation of bubbles in the liquid (ink) in one-to-one correspondence to the drive signal. Growth or contraction of the bubbles causes the liquid (ink) to be ejected through the ejection opening, thus forming at least one droplet. The drive signal in the form of a pulse is much preferable because the bubbles can grow or be contracted instantaneously and appropriately, and thus, the liquid (ink) can be ejected with remarkably high responsiveness. A signal disclosed in U.S. Patent No. 4,463,359 or 4,345,262 may be suitable for the drive signal in the form of a pulse. More excellent recording can be achieved by using conditions disclosed in U.S. Patent No.

4,313,124 relating to a temperature increasing rate at the heat acting surface.

[0071]

The configurations of the recording heads according to the present invention include the configuration disclosed in U.S. Patent No. 4,558,333 or 4,459,600 in which the heat acting surface is located in a bent region beside the configuration in which the ejection openings, the liquid paths and the electrothermal transducers are combined with each other (a linear liquid channel or a rectangular liquid channel) as disclosed in the aforementioned specifications. Additionally, the effect according to the present invention may be produced in the configuration disclosed in Japanese Patent Application Laid-open No. 123,670/1984 in which slots common to a plurality of electrothermal transducers are used as ejection openings of the electrothermal transducers, or in the configuration disclosed in Japanese Patent Application Laid-open No. 138,461/1984 in which openings for absorbing a pressure wave of thermal energy correspond to ejection openings. That is, recording operation may be securely performed with efficiency according to the present invention irrespective of whatever the configuration of the recording head is.

[0072]

Furthermore, the recording head of a full-line type having a length corresponding to the maximum width of the recording medium which can be recorded by the recording apparatus may take either one of the configuration in which a plurality of recording heads are combined to cover the length and the configuration of one recording head formed integrally.

[0073]

Additionally, there may be used not only the recording head of the cartridge type in which an ink tank is disposed integrally with the recording head per se, as described in the above embodiment, but also a recording head of a replaceable chip type in which the head is fixed to the apparatus body to be electrically connected to the apparatus body or ink can be supplied from the apparatus body.

[0074]

It is preferable that ejection recovering means, preliminarily auxiliary means or the like for the recording head should be additionally disposed as constituents of the recording apparatus according to the present invention, thus further stabilizing the advantageous results of the present invention. There are specifically listed capping means with respect to the recording head, cleaning means, pressurizing or sucking means, preliminarily heating means for

performing heating by the use of the thermoelectric transducer, other heating elements, or the combination thereof, and preliminarily ejecting means for performing ejection other than recording.

[0075]

With respect to the kind or number of recording heads to be installed, only one recording head may be provided in a fashion corresponding to monochromatic ink, or a plurality of recording heads may be provided in a fashion corresponding to a plurality of inks different in color or concentration. That is, the present invention can be effectively applicable to recording apparatuses in not only a recording mode in only one main color such as black but also a full-color recording mode in different or mixed colors by using either an integral ink-jet head or a plurality of recording heads in combination.

[0076]

Although the ink in the state of liquid has been explained in the above-described embodiments according to the present invention, there may be used ink which is solidified at room temperature or lower and softened or liquefied at room temperature. Otherwise, since in the ink-jet system, the temperature of the ink is generally controlled so as to keep the viscosity of the ink within a stable ejection range by adjusting the temperature of the ink per se within the

range from 30 °C to 70 °C, there may be used ink which becomes liquefied at the time of application of a used recording signal. Additionally, ink which is solid in a left state while is liquefied by heating may be used in order to aggressively prevent an increase in temperature due to thermal energy which is used as energy for transforming the ink from solid to liquid, or to prevent any evaporation of the ink. Anyway, the present invention is applicable to the case using ink having a property which is first liquefied with application of thermal energy, such as ink which is liquefied with application of thermal energy in response to a print signal to be ejected in a liquid state, ink which has started to be solidified already at the time when it reaches a medium to be printed, or the like. As disclosed in Japanese Patent Application Laid-open No. 56847/1979 or 71260/1985, such ink may be disposed opposite to the thermoelectric transducer in a manner held in a liquid or solid state in a recess or through hole formed at a porous sheet. According to the present invention, the above-described film boiling system is most effective for each of the above-described inks.

[0077]

Furthermore, the ink-jet recording apparatus according to the present invention may be used as an image output terminal for information processing

equipment such as a computer, a copy machine combined with a reader, a facsimile apparatus having a transmitting/receiving function, or the like.

[0078]

[Advantageous Results of the Invention]

As described above, according to the present invention, the ejection amount is reduced in comparison with the case where the pulses are simultaneously applied to all of the heaters by shifting the pulse applying timings of the plurality of heaters in such a manner that the reduced amount becomes greater as the shifted timing becomes longer. In this configuration, the shifted timing is varied based on the information relating to the ink temperature of the ink-jet head. Therefore, even if the ejection amount is to be increased according to the ink temperature rise, the increase in ejection amount can be suppressed by lengthening the shifted timing, thereby stabilizing the ejection amount.

[0079]

Consequently, it is possible to eject the ink in the stable ejection amount even if the temperature of the ink-jet head or the environmental temperature is varied.

[0080]

Furthermore, it is possible to enlarge the range of the (stable) ejection amount control in comparison

with the conventional ejection amount stabilizing/controlling method.

[BRIEF DESCRIPTION OF THE DRAWINGS]

[Fig. 1]

Fig. 1 is a perspective view showing an ink-jet printing apparatus in a first embodiment according to the present invention.

[Fig. 2]

Fig. 2 is a block diagram illustrating mainly a control system of the printing apparatus.

[Fig. 3]

Fig. 3 is a cross-sectional view showing an ink-jet head and an ink tank cartridge for use in the apparatus.

[Fig. 4]

Figs. 4(a) and 4(b) are cross-sectional views showing the structure of the ink-jet head in the first embodiment according to the present invention.

[Fig. 5]

Fig. 5 is a graph illustrating the environmental temperature dependency of an ejection amount of the ink-jet head.

[Fig. 6]

Fig. 6(a) schematically illustrates pulses to be simultaneously applied to two heaters, and Fig. 6(b) schematically illustrates pulses to be applied with a period shifted.

[Fig. 7]

Fig. 7 is a graph illustrating the relationship between an ink ejection amount and the shifted period.

[Fig. 8]

Fig. 8 illustrates a shifted period table in the first embodiment according to the present invention.

[Fig. 9]

Fig. 9 is a graph illustrating an ejection amount control mode in a preferred embodiment according to the present invention.

[Fig. 10]

Fig. 10 is a flowchart illustrating shifting control sequence in the ejection amount control.

[Fig. 11]

Fig. 11 illustrates a shifted period table in a second embodiment according to the present invention.

[Fig. 12]

Fig. 12 illustrates a shifted period table in a third embodiment according to the present invention.

[Fig. 13]

Fig. 13 is a cross-sectional view showing the structure of an ink-jet head in a fourth embodiment according to the present invention.

[Fig. 14]

Fig. 14 is a graph illustrating the head temperature dependency of an ink ejection amount in each ejection mode in the fourth embodiment.

[Fig. 15]

Fig. 15 is a graph illustrating the relationship between a shifted period and an ejection amount in the fourth embodiment.

[Fig. 16]

Figs. 16(a) and 16(b) illustrate shifted period tables in the fourth embodiment according to the present invention.

[Fig. 17]

Figs. 17(a) and 17(b) illustrate shifted period tables in a fifth embodiment according to the present invention.

[Fig. 18]

Fig. 18 is a cross-sectional view showing the structure of an ink-jet head in another embodiment according to the present invention.

[Fig. 19]

Fig. 19 is a cross-sectional view showing the structure of an ink-jet head in a further embodiment according to the present invention.

[REFERENCE NUMERALS]

2, 2Y, 2M, 2C, 2Bk ... ink-jet head

2A ... ink path

2N ... ejection opening

200 ... controller

SH1, SH2 ... heater

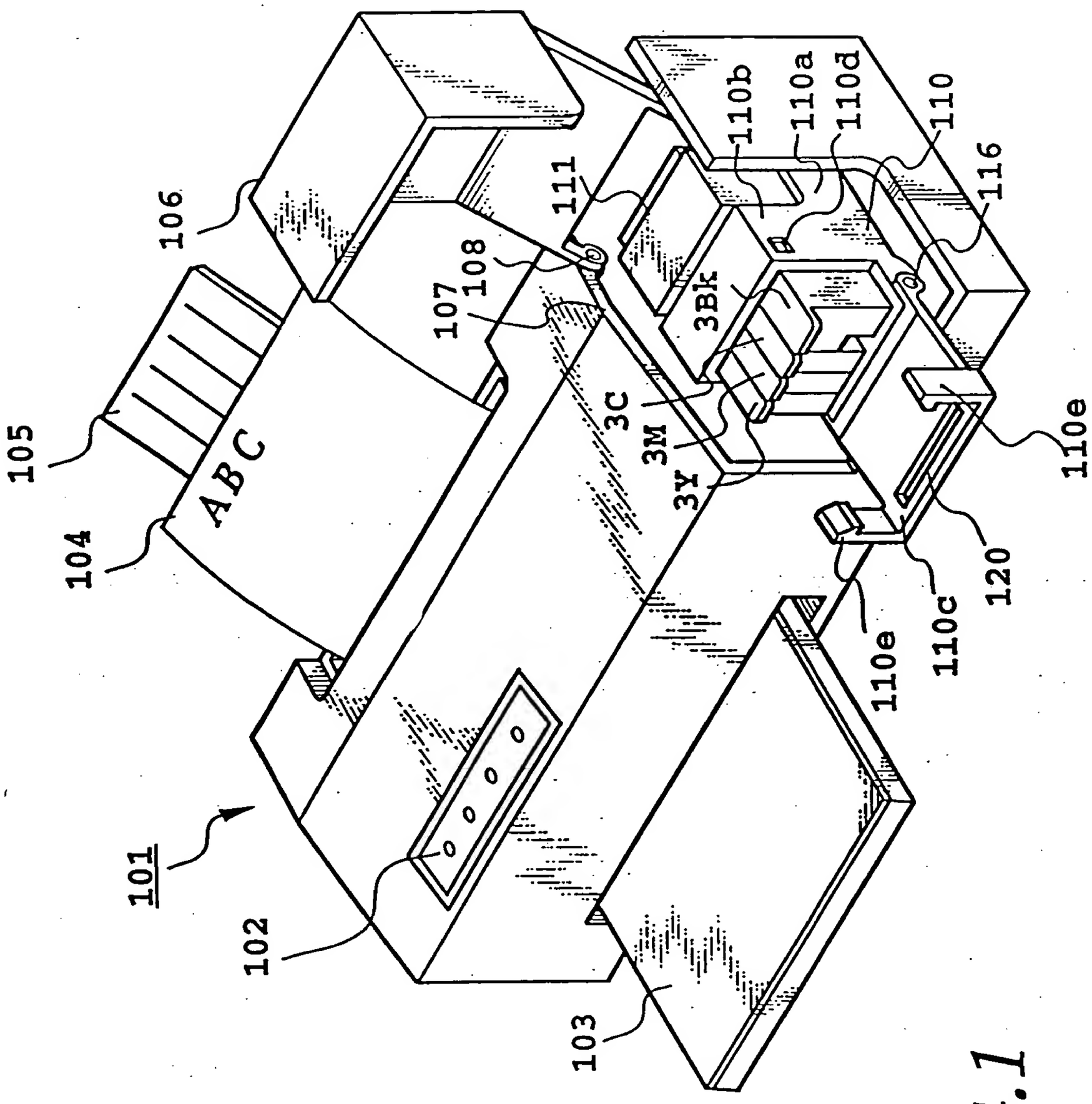
106
105
104
ABC
107
108
111
110b
110a
110d
110
116
3C
3M
3Y
3Bk
110e
110c
120
101
102
103

FIG.1

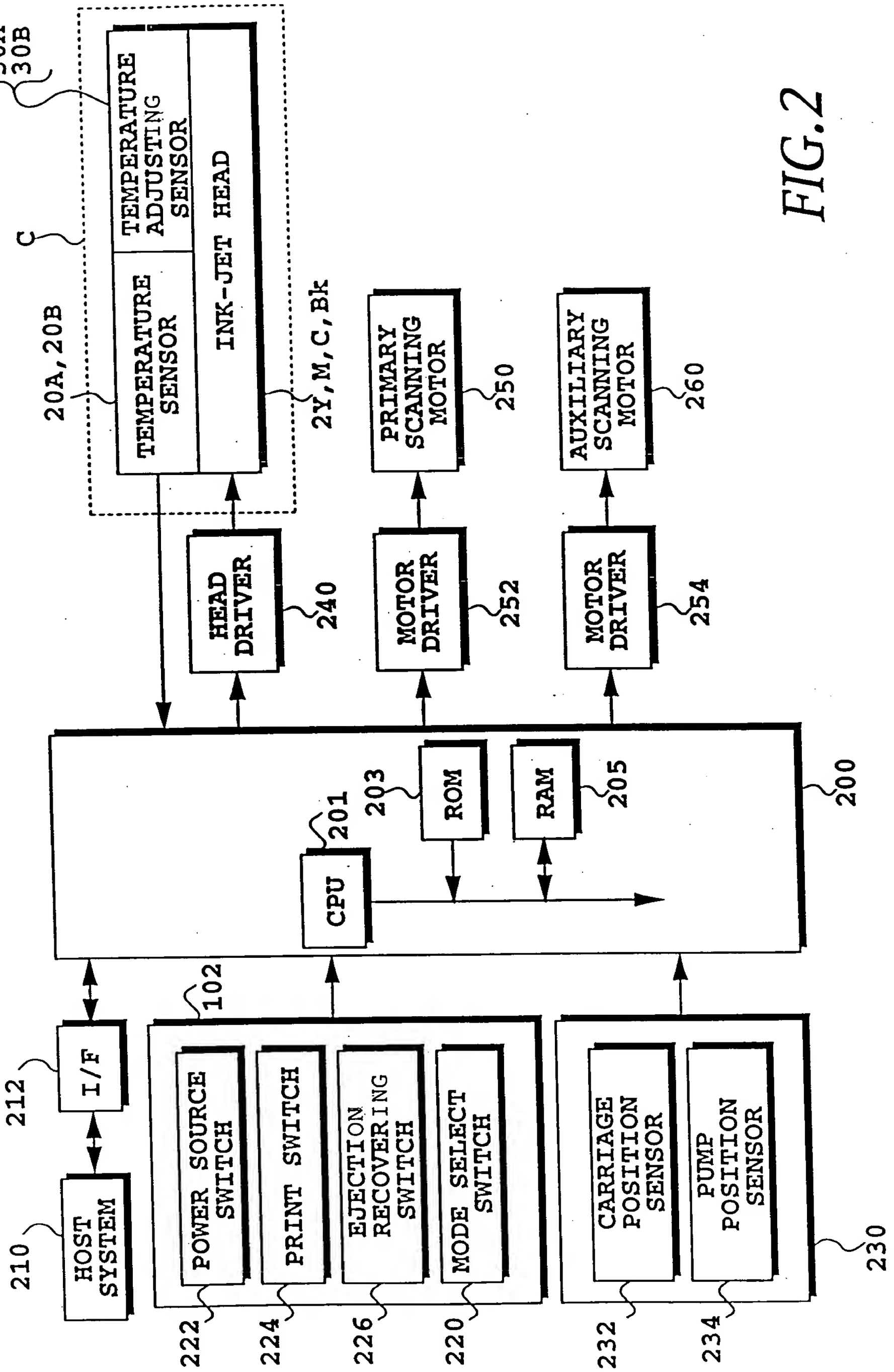
30A
30B
C
20A, 20B
TEMPERATURE ADJUSTING SENSOR
TEMPERATURE SENSOR
INK-JET HEAD
2Y, M, C, Bk
PRIMARY SCANNING MOTOR
250
AUXILIARY SCANNING MOTOR
260
HEAD DRIVER
240
MOTOR DRIVER
252
MOTOR DRIVER
254
CPU
201
203
ROM
RAM
205
200
I/F
212
HOST SYSTEM
210
102
POWER SOURCE SWITCH
PRINT SWITCH
EJECTION RECOVERING SWITCH
MODE SELECT SWITCH
222
224
226
220
CARRIAGE POSITION SENSOR
PUMP POSITION SENSOR
232
234
230

FIG.2

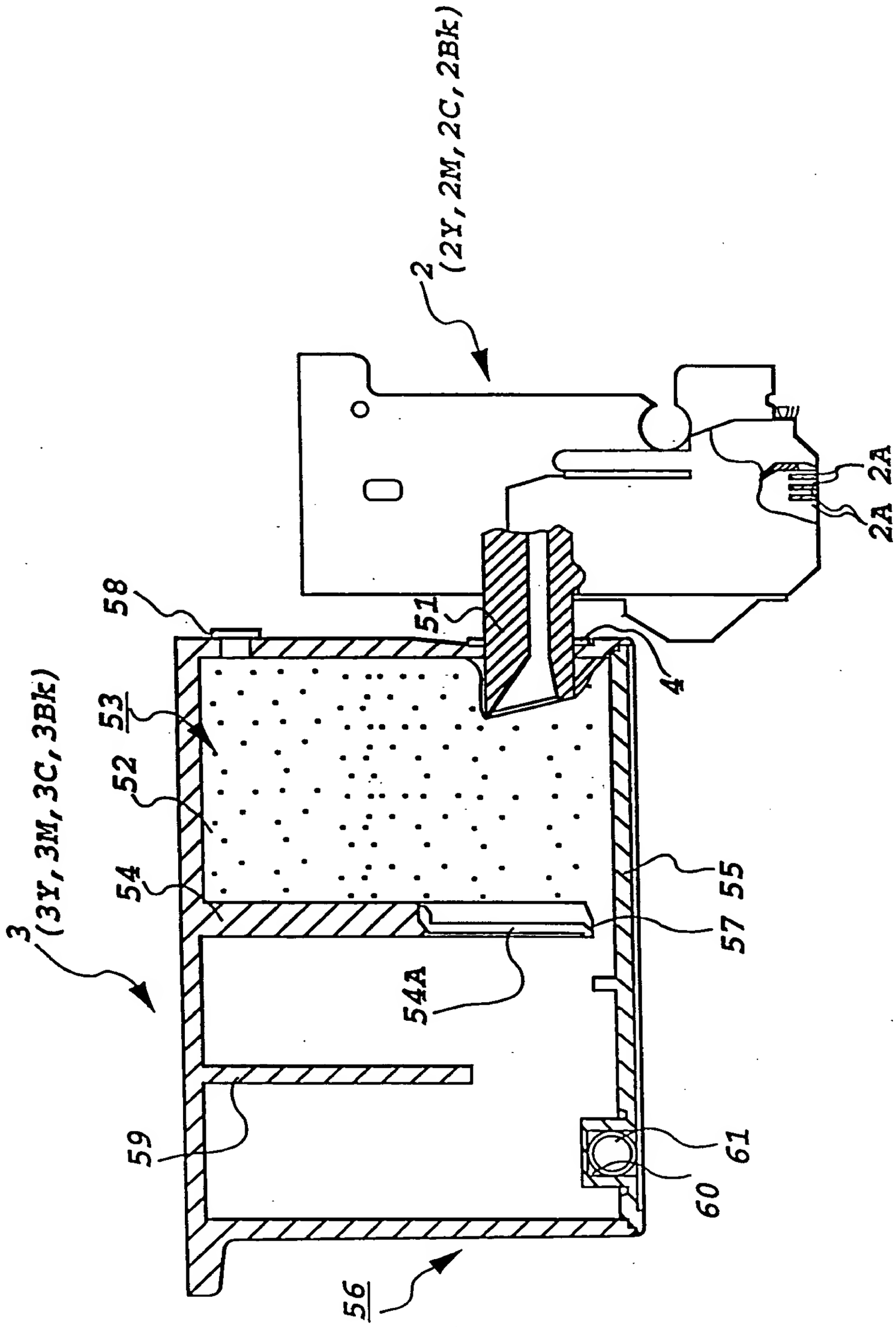
2
(2Y, 2M, 2C, 2Bk)
2A
2A
58
51
4
53
52
54
3
(3Y, 3M, 3C, 3Bk)
57
55
54A
59
61
60
56

FIG.3

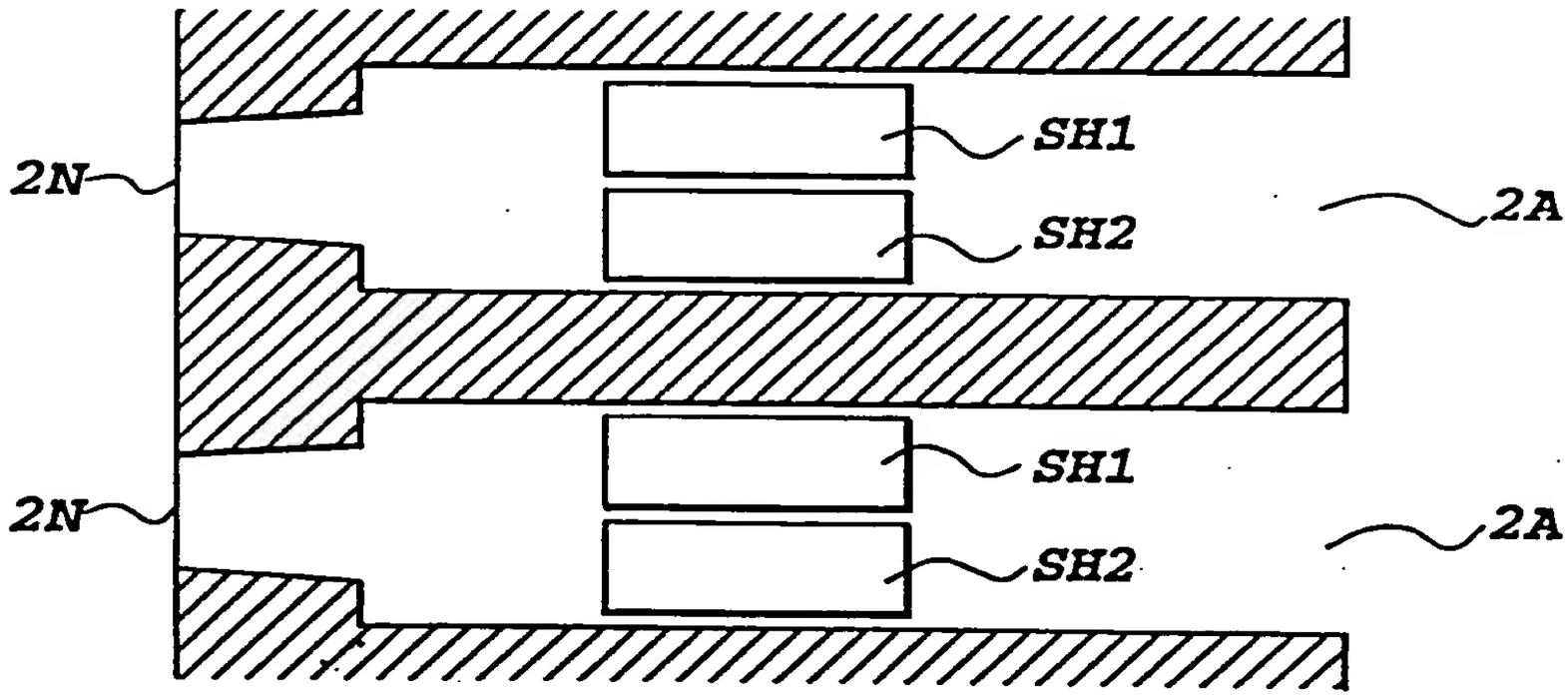

FIG.4A

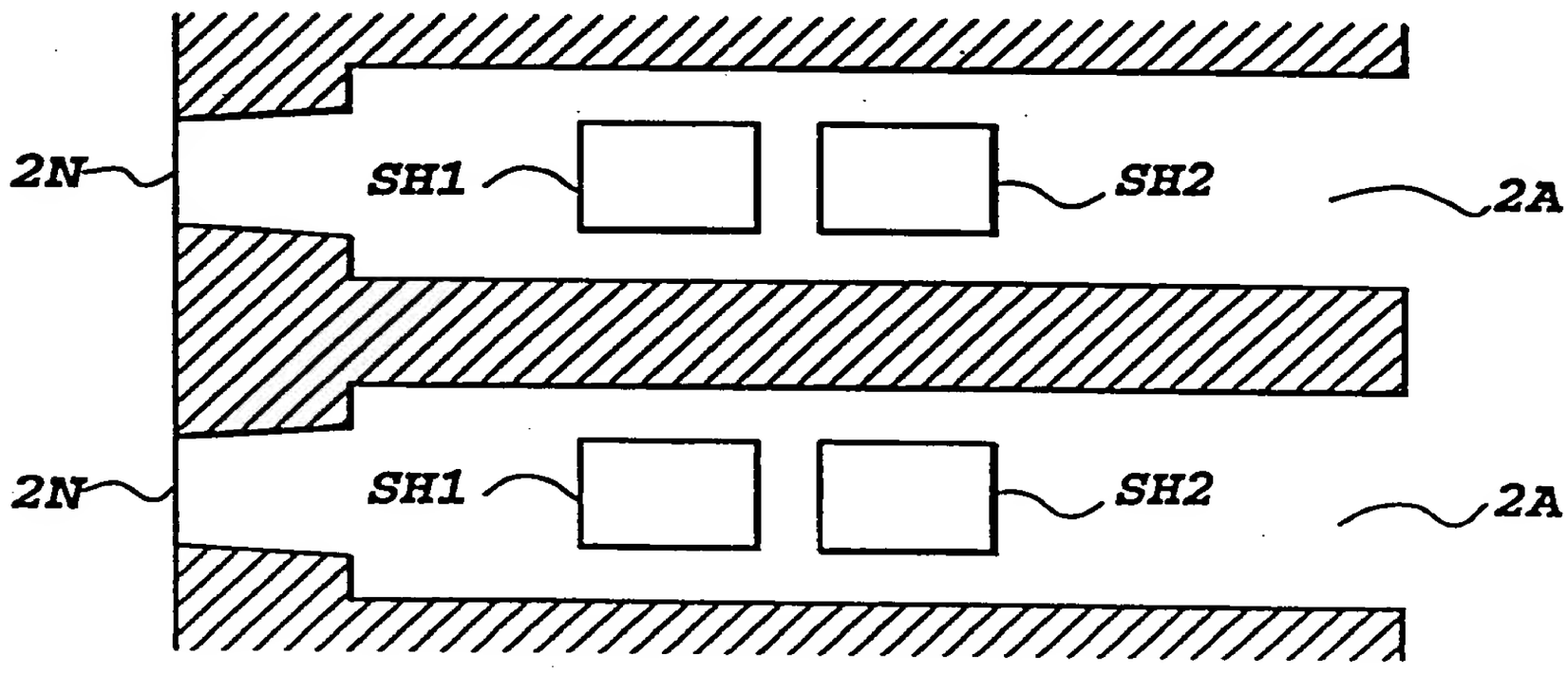

FIG.4B

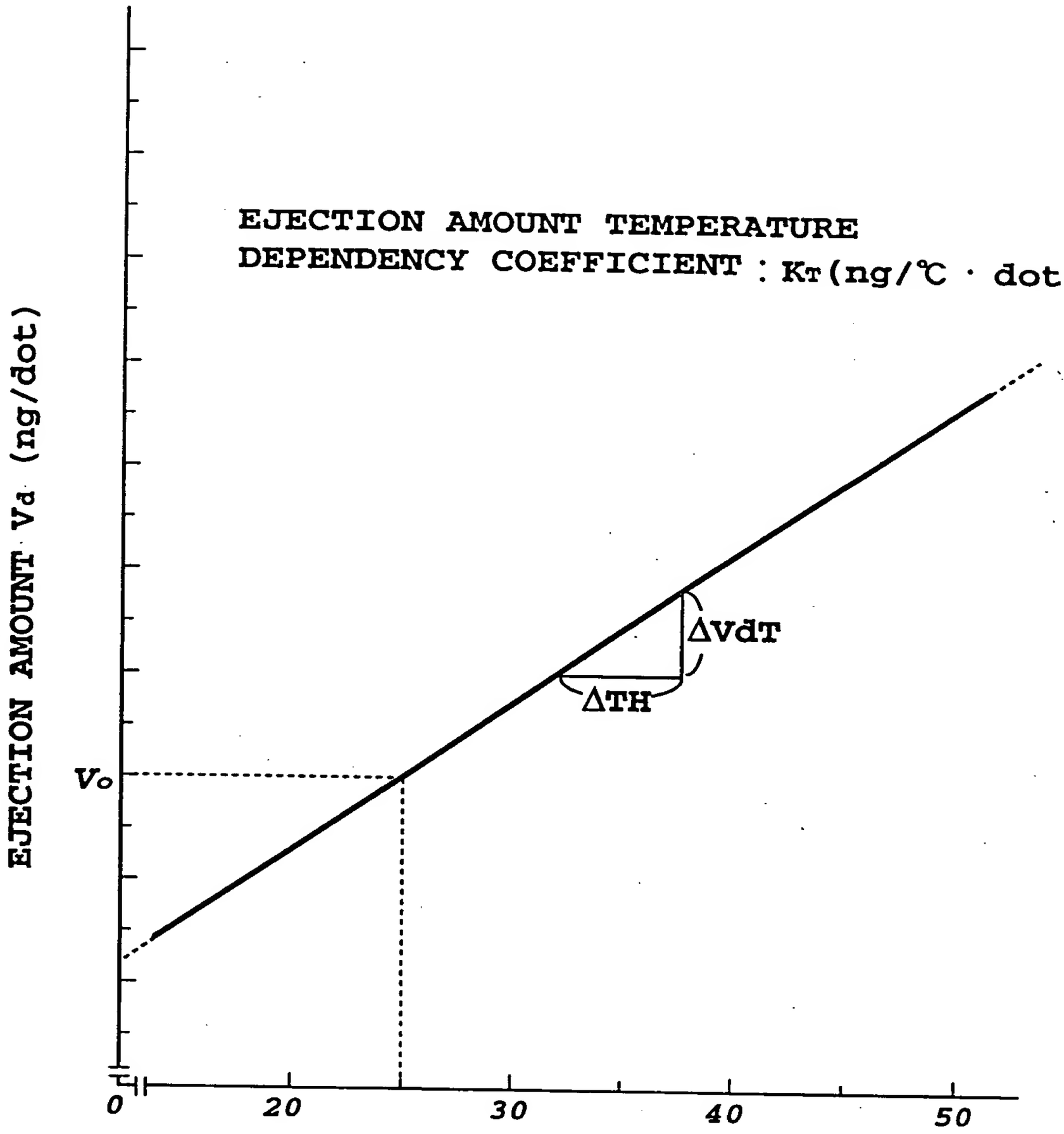
EJECTION AMOUNT TEMPERATURE
DEPENDENCY COEFFICIENT : KT(ng/℃ · dot)
EJECTION AMOUNT Va (ng/dot)
ΔvdT
ΔTH
Vo
0
20
30
40
50
ENVIRONMENTAL TEMPERATURE TR (℃)

FIG.5

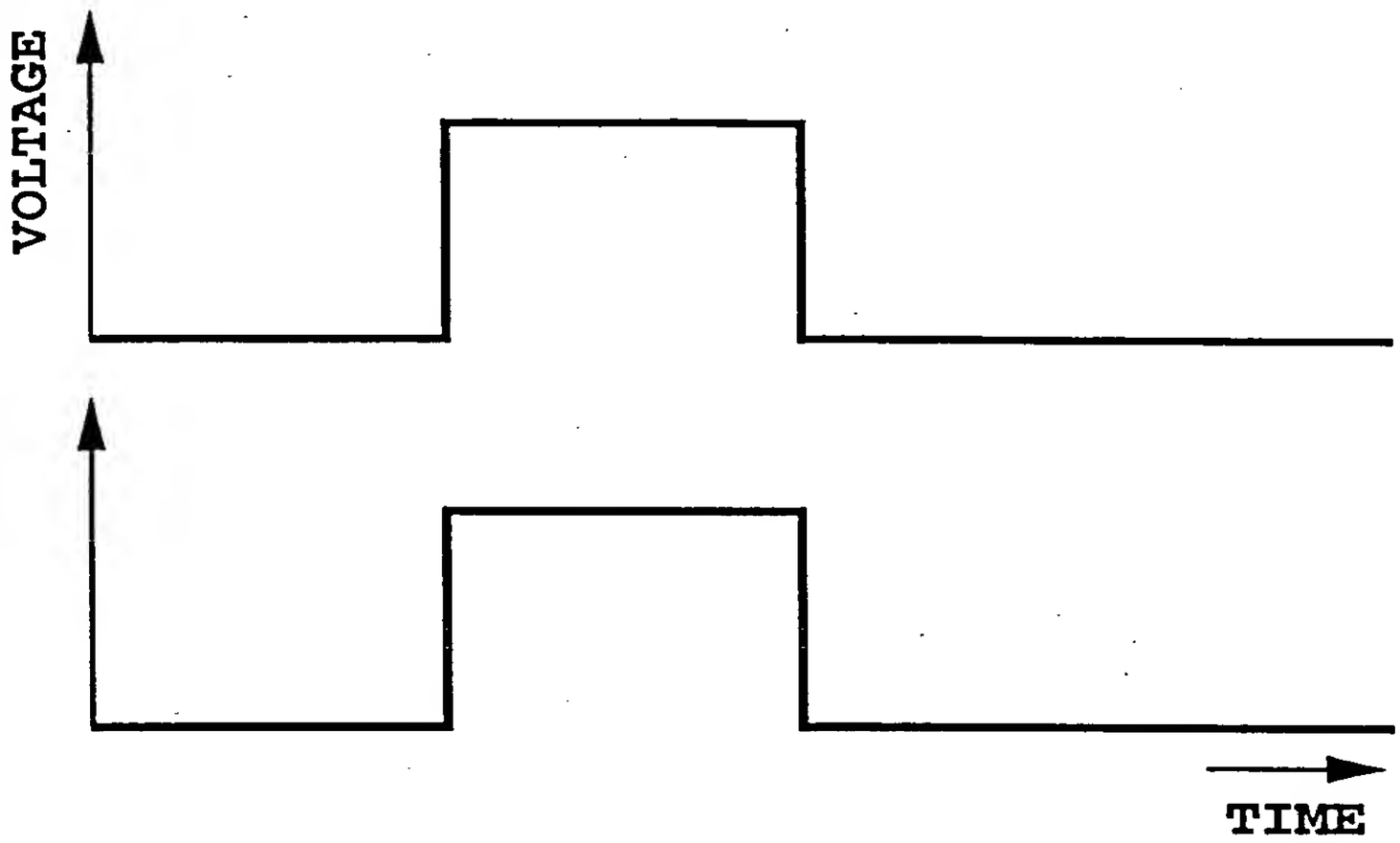

FIG. 6(a)

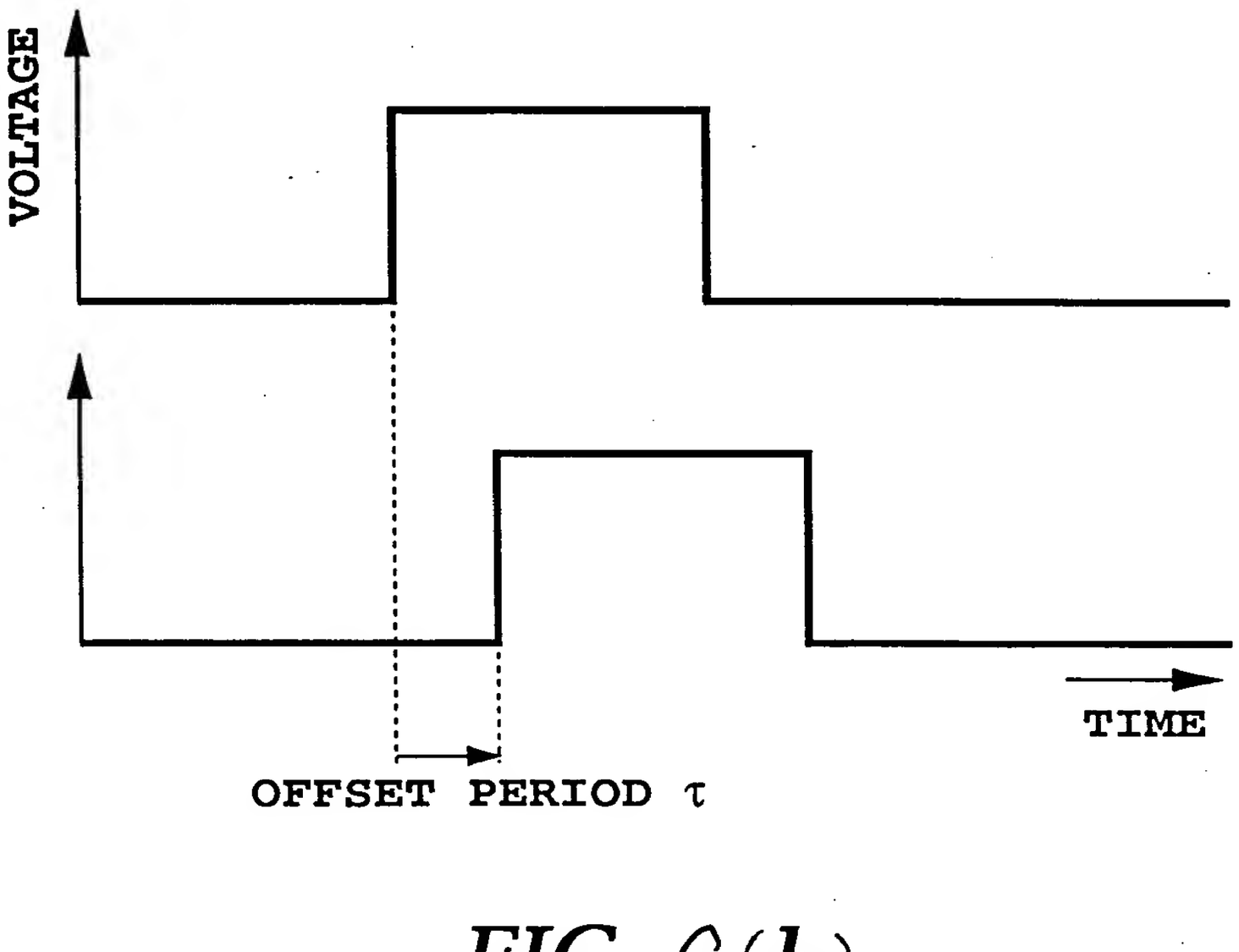

FIG. 6(b)

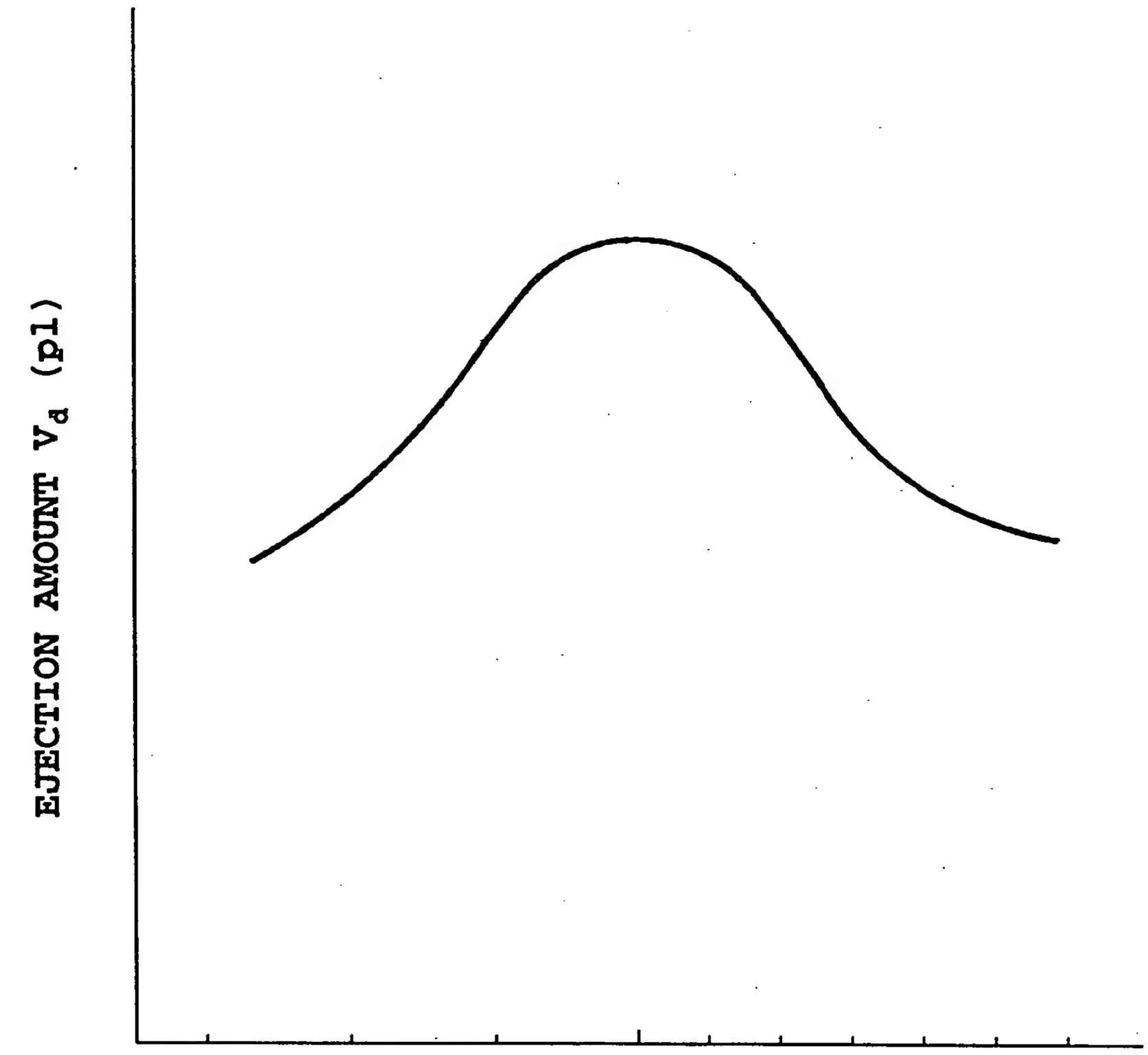

FIG. 7

TABLE NO.	①	②	③	④	⑤	⑥	⑦	⑧	⑨	⑩	⑪
HEAD TEMPERATURE Th (°C)	LOWER THAN 26	26 OR HIGHER ~ LOWER THAN 29	29 OR HIGHER ~ LOWER THAN 32	32 OR HIGHER ~ LOWER THAN 35	35 OR HIGHER ~ LOWER THAN 38	38 OR HIGHER ~ LOWER THAN 41	41 OR HIGHER ~ LOWER THAN 44	44 OR HIGHER ~ LOWER THAN 47	47 OR HIGHER ~ LOWER THAN 50	50 OR HIGHER ~ LOWER THAN 53	53 OR HIGHER
SHIFTED PERIOD τ(μsec)	0	0.8	1.2	1.5	1.8	2.1	2.4	2.7	3.0	3.4	4.0

FIG. 8

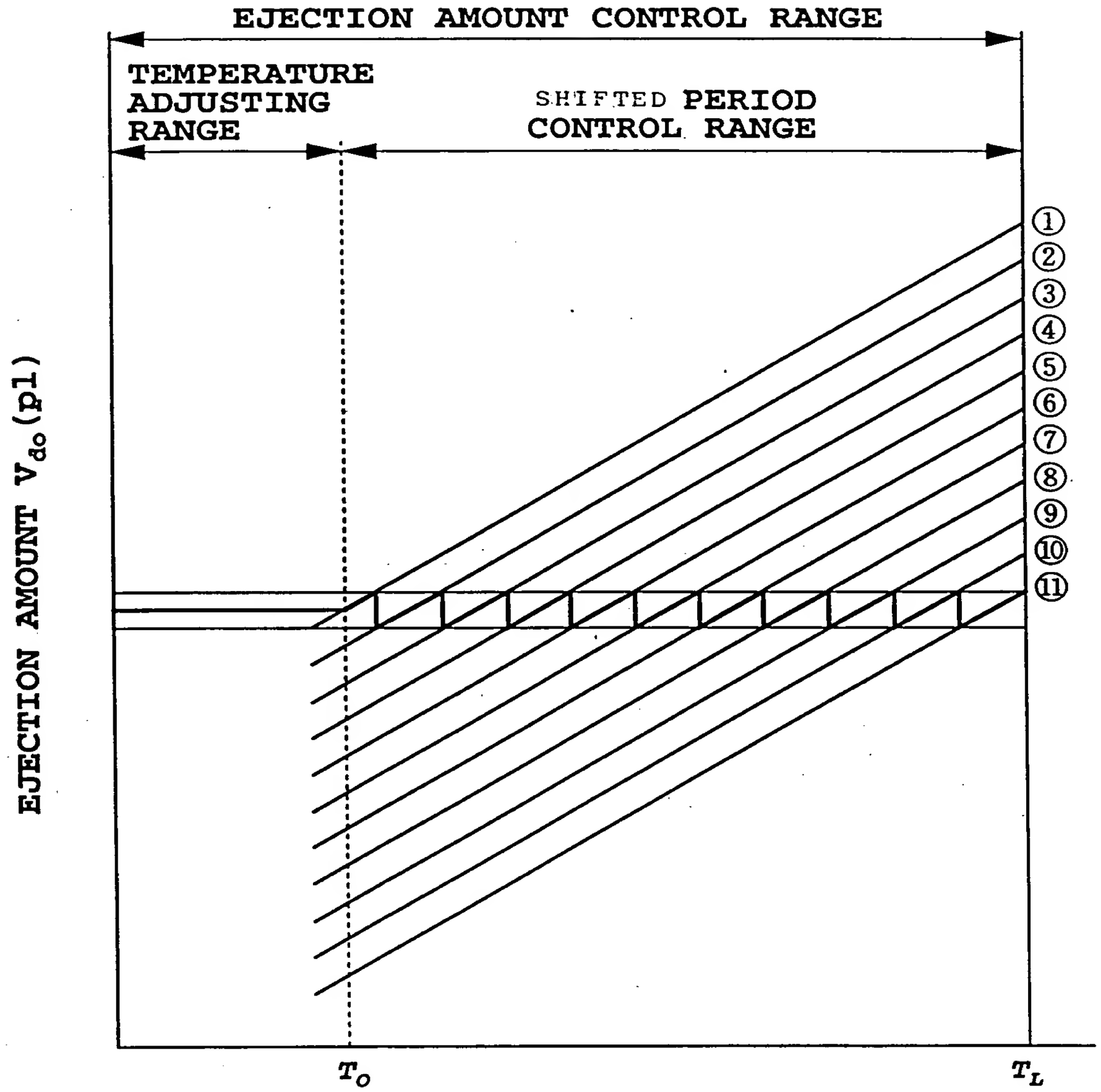
EJECTION AMOUNT CONTROL RANGE
TEMPERATURE ADJUSTING RANGE
SHIFTED PERIOD CONTROL RANGE
①
②
③
④
⑤
⑥
⑦
⑧
⑨
⑩
⑪
EJECTION AMOUNT V_{do} (pl)
T_o
T_L
HEAD TEMPERATURE T_h (℃)

FIG. 9

FIG.10

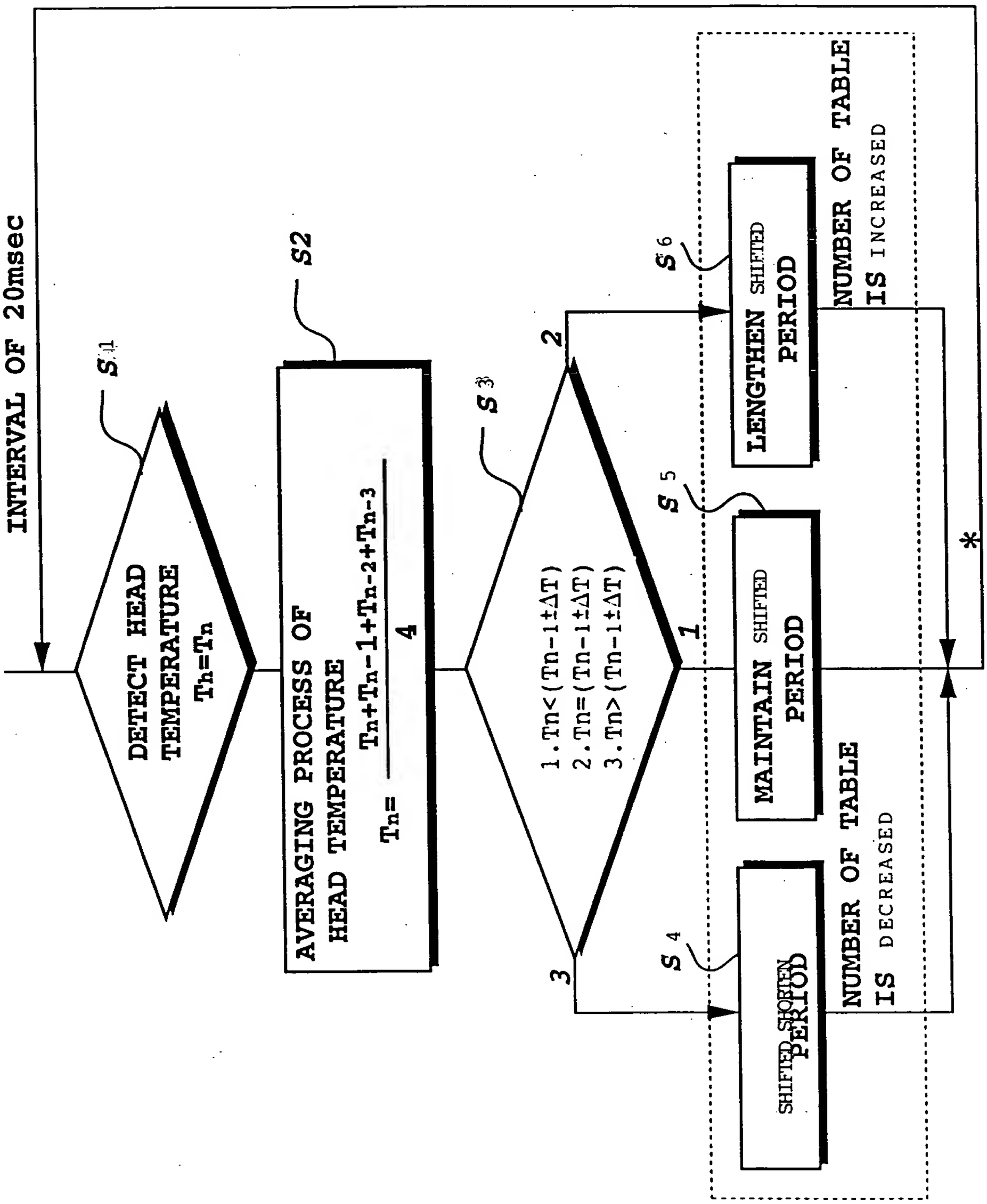
INTERVAL OF 20msec
S1
DETECT HEAD TEMPERATURE
Th=Tn
S2
AVERAGING PROCESS OF HEAD TEMPERATURE
Tn= (Tn+Tn-1+Tn-2+Tn-3)/4
S3
1. Tn<(Tn-1±ΔT)
2. Tn=(Tn-1±ΔT)
3. Tn>(Tn-1±ΔT)
1
MAINTAIN SHIFTED PERIOD
S5
2
LENGTHEN SHIFTED PERIOD
S6
3
SHORTEN SHIFTED PERIOD
S4
NUMBER OF TABLE IS INCREASED
NUMBER OF TABLE IS DECREASED
*
INHIBIT TABLE JUMP

TABLE NO.	①	②	③	④	⑤	⑥	⑦	⑧	⑨	⑩	⑪
HEAD TEMPERATURE Th (°C)	LOWER THAN 26	26 OR HIGHER ~ LOWER THAN 29	29 OR HIGHER ~ LOWER THAN 32	32 OR HIGHER ~ LOWER THAN 35	35 OR HIGHER ~ LOWER THAN 38	38 OR HIGHER ~ LOWER THAN 41	41 OR HIGHER ~ LOWER THAN 44	44 OR HIGHER ~ LOWER THAN 47	47 OR HIGHER ~ LOWER THAN 50	50 OR HIGHER ~ LOWER THAN 53	53 OR HIGHER
SHIFTED PERIOD τ(μsec)	0	-0.8	-1.2	-1.5	-1.8	-2.1	-2.4	-2.7	-3.0	-3.4	-4.0

FIG.11

TABLE NO.	①	②	③	④	⑤	⑥	⑦	⑧
HEAD TEMPERATURE Th (°C)	LOWER THAN 26	26 OR HIGHER ~ LOWER THAN 29	29 OR HIGHER ~ LOWER THAN 32	32 OR HIGHER ~ LOWER THAN 35	35 OR HIGHER ~ LOWER THAN 38	38 OR HIGHER ~ LOWER THAN 41	41 OR HIGHER ~ LOWER THAN 44	44 OR HIGHER
SHIFTED PERIOD τ (μsec)	1.2	1.5	1.8	2.1	2.4	2.7	3.0	3.3

FIG.12

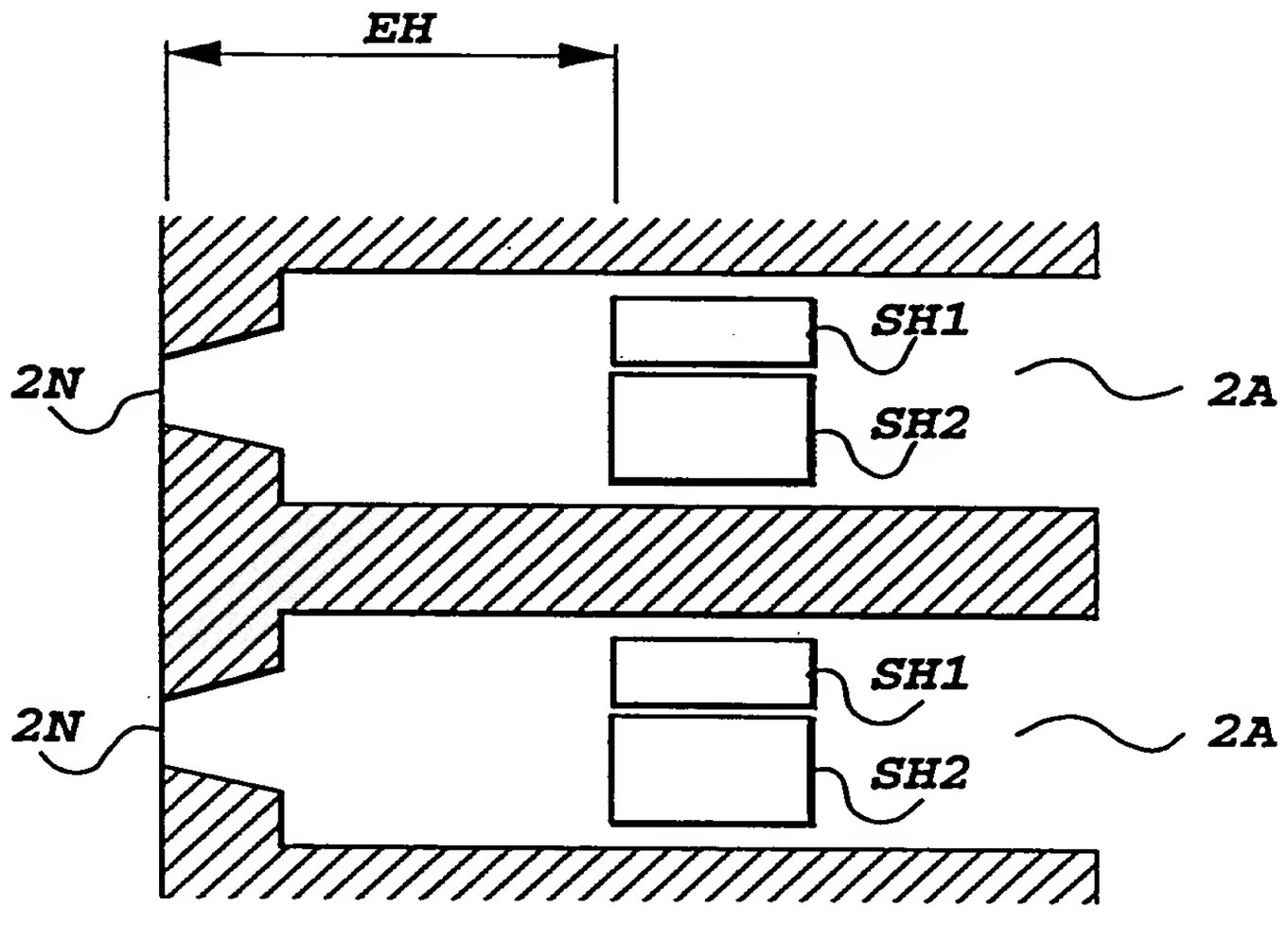

FIG. 13

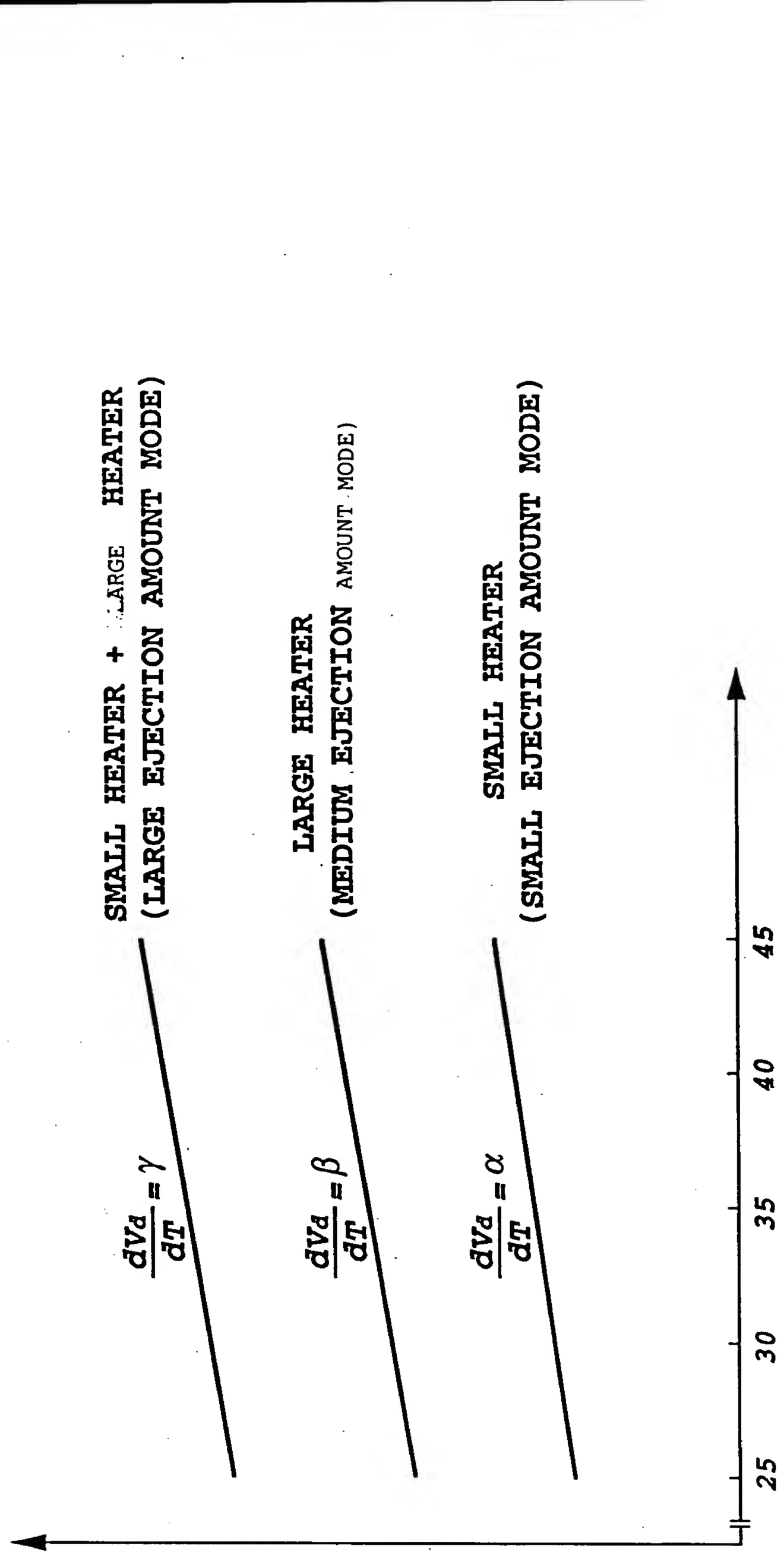
SMALL HEATER + LARGE HEATER
(LARGE EJECTION AMOUNT MODE)
LARGE HEATER
(MEDIUM EJECTION AMOUNT MODE)
SMALL HEATER
(SMALL EJECTION AMOUNT MODE)
$\frac{dV_d}{dT} = \gamma$
$\frac{dV_d}{dT} = \beta$
$\frac{dV_d}{dT} = \alpha$
30
35
40
45
25
HEAD TEMPERATURE T_h (°C)
EJECTION AMOUNT V_d (pl)

FIG.14

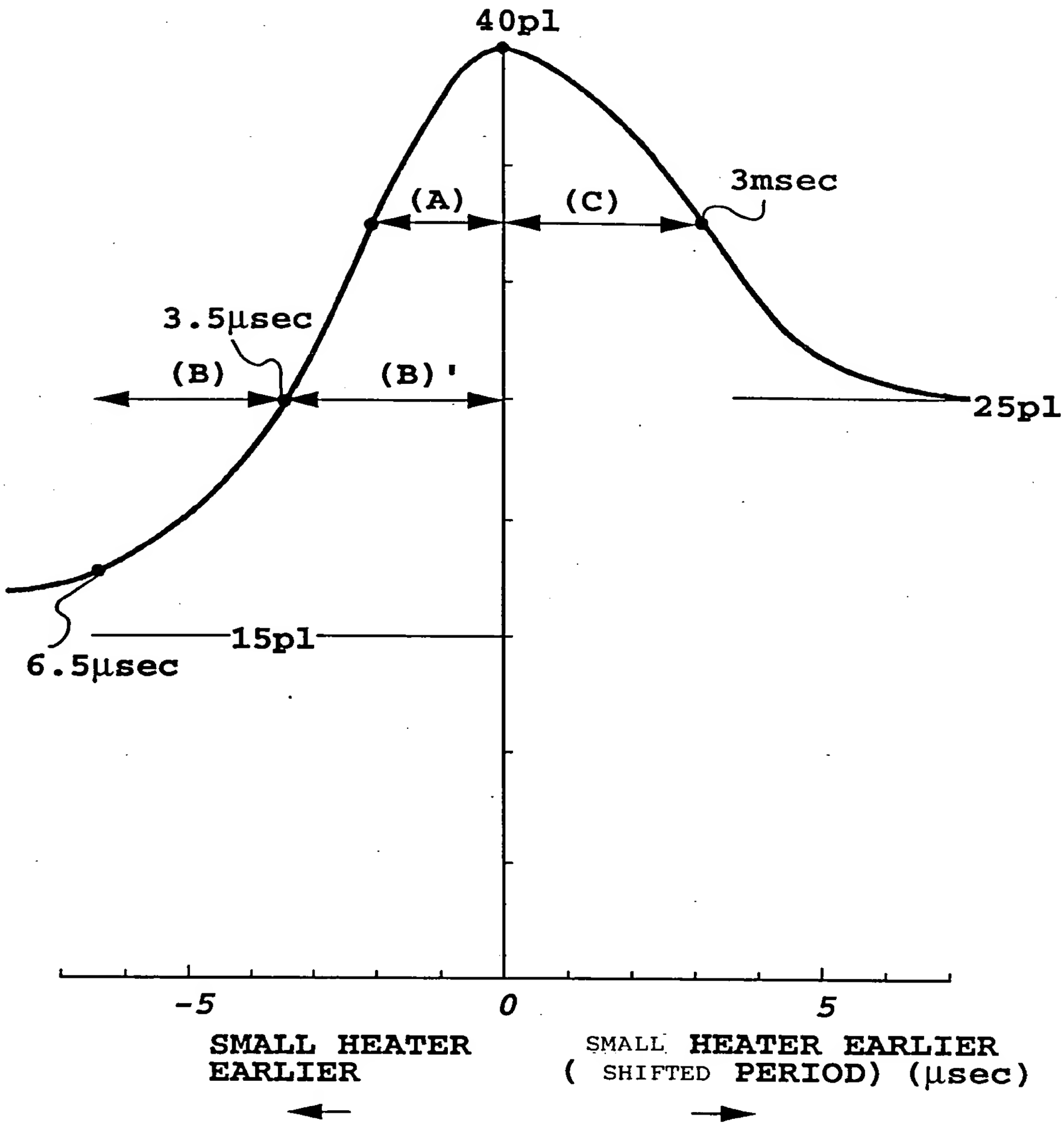
40pl
3msec
(A)
(C)
3.5μsec
(B)
(B)'
25pl
15pl
6.5μsec
-5
0
5
SMALL HEATER EARLIER
SMALL HEATER EARLIER
(SHIFTED PERIOD) (μsec)

FIG. 15

LARGE EJECTION AMOUNT MODE (40pl/dot)

TABLE NO.	①	②	③	④	⑤	⑥	⑦	⑧	⑨	⑩
HEAD TEMPERATURE Th (℃)	LOWER THAN 26	26 OR HIGHER ~ LOWER THAN 29	29 OR HIGHER ~ LOWER THAN 32	32 OR HIGHER ~ LOWER THAN 35	35 OR HIGHER ~ LOWER THAN 38	38 OR HIGHER ~ LOWER THAN 41	41 OR HIGHER ~ LOWER THAN 44	44 OR HIGHER ~ LOWER THAN 47	47 OR HIGHER ~ LOWER THAN 50	50 OR HIGHER
SHIFTED PERIOD τ(μsec)	0	0.4	0.6	0.8	1.0	1.2	1.4	1.6	1.8	2.0

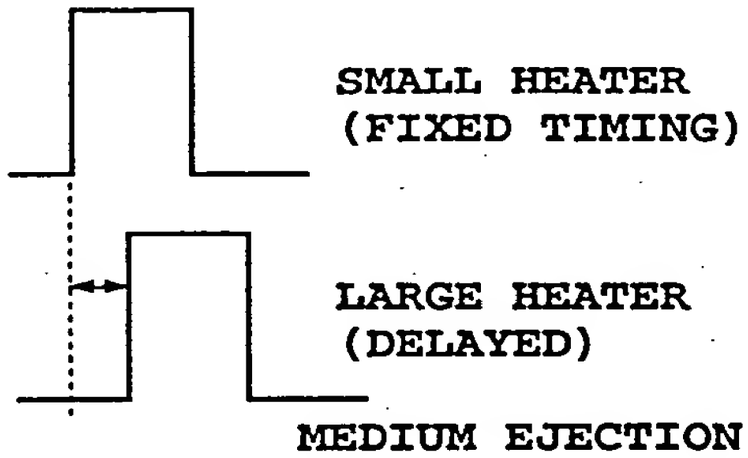

FIG. 16(a)

MEDIUM EJECTION AMOUNT MODE (25pl/dot)

TABLE NO.	①	②	③	④	⑤	⑥	⑦	⑧	⑨	⑩
HEAD TEMPERATURE Th (℃)	LOWER THAN 26	26 OR HIGHER ~ LOWER THAN 29	29 OR HIGHER ~ LOWER THAN 32	32 OR HIGHER ~ LOWER THAN 35	35 OR HIGHER ~ LOWER THAN 38	38 OR HIGHER ~ LOWER THAN 41	41 OR HIGHER ~ LOWER THAN 44	44 OR HIGHER ~ LOWER THAN 47	47 OR HIGHER ~ LOWER THAN 50	50 OR HIGHER
PERIOD τ(μsec)	3.5	3.8	4.1	4.4	4.7	5.0	5.3	5.7	6.1	6.5

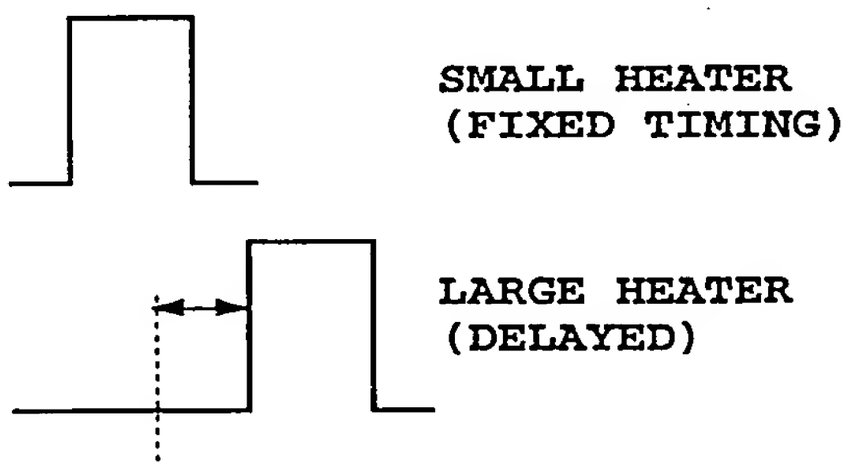

FIG. 16(b)

LARGE EJECTION AMOUNT MODE (40pl/dot)

TABLE NO.	①	②	③	④	⑤	⑥	⑦	⑧	⑨	⑩
HEAD TEMPERATURE Th (℃)	LOWER THAN 26	26 OR HIGHER ~ LOWER THAN 29	29 OR HIGHER ~ LOWER THAN 32	32 OR HIGHER ~ LOWER THAN 35	35 OR HIGHER ~ LOWER THAN 38	38 OR HIGHER ~ LOWER THAN 41	41 OR HIGHER ~ LOWER THAN 44	44 OR HIGHER ~ LOWER THAN 47	47 OR HIGHER ~ LOWER THAN 50	50 OR HIGHER
SHIFTED PERIOD τ(μsec)	0	0.6	0.9	1.2	1.5	1.8	2.1	2.4	2.7	3.0

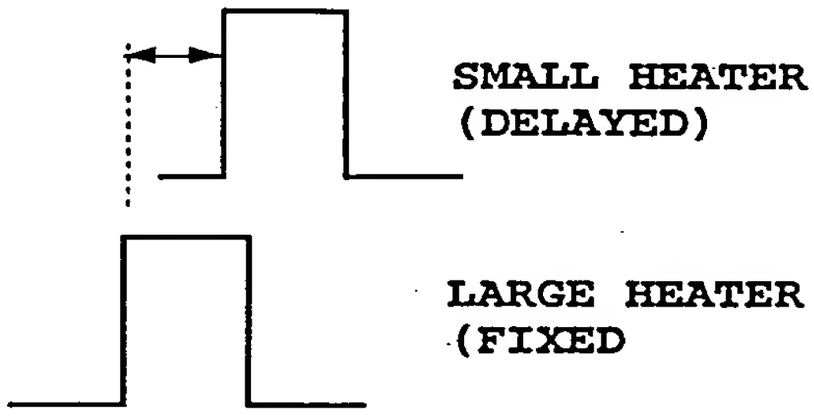

FIG. 17(a)

MEDIUM EJECTION AMOUNT MODE (25pl/dot)

TABLE NO.	①	②	③	④	⑤	⑥	⑦	⑧	⑨	⑩
HEAD TEMPERATURE Th (℃)	LOWER THAN 26	25 OR HIGHER ~ LOWER THAN 29	29 OR HIGHER ~ LOWER THAN 32	32 OR HIGHER ~ LOWER THAN 35	35 OR HIGHER ~ LOWER THAN 38	38 OR HIGHER ~ LOWER THAN 41	41 OR HIGHER ~ LOWER THAN 44	44 OR HIGHER ~ LOWER THAN 47	47 OR HIGHER ~ LOWER THAN 50	50 OR HIGHER
SHIFTED PERIOD τ(μsec)	3.5	3.8	4.1	4.4	4.7	5.0	5.3	5.7	6.1	6.5

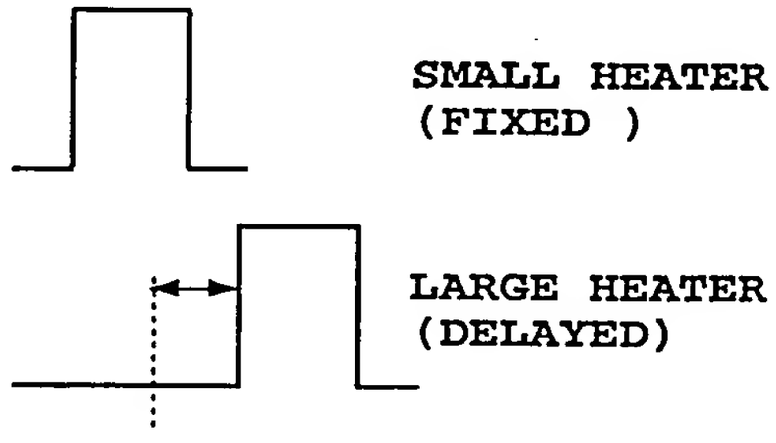

FIG. 17(b)

SH1: SMALL HEATER
SH2: LARGE HEATER

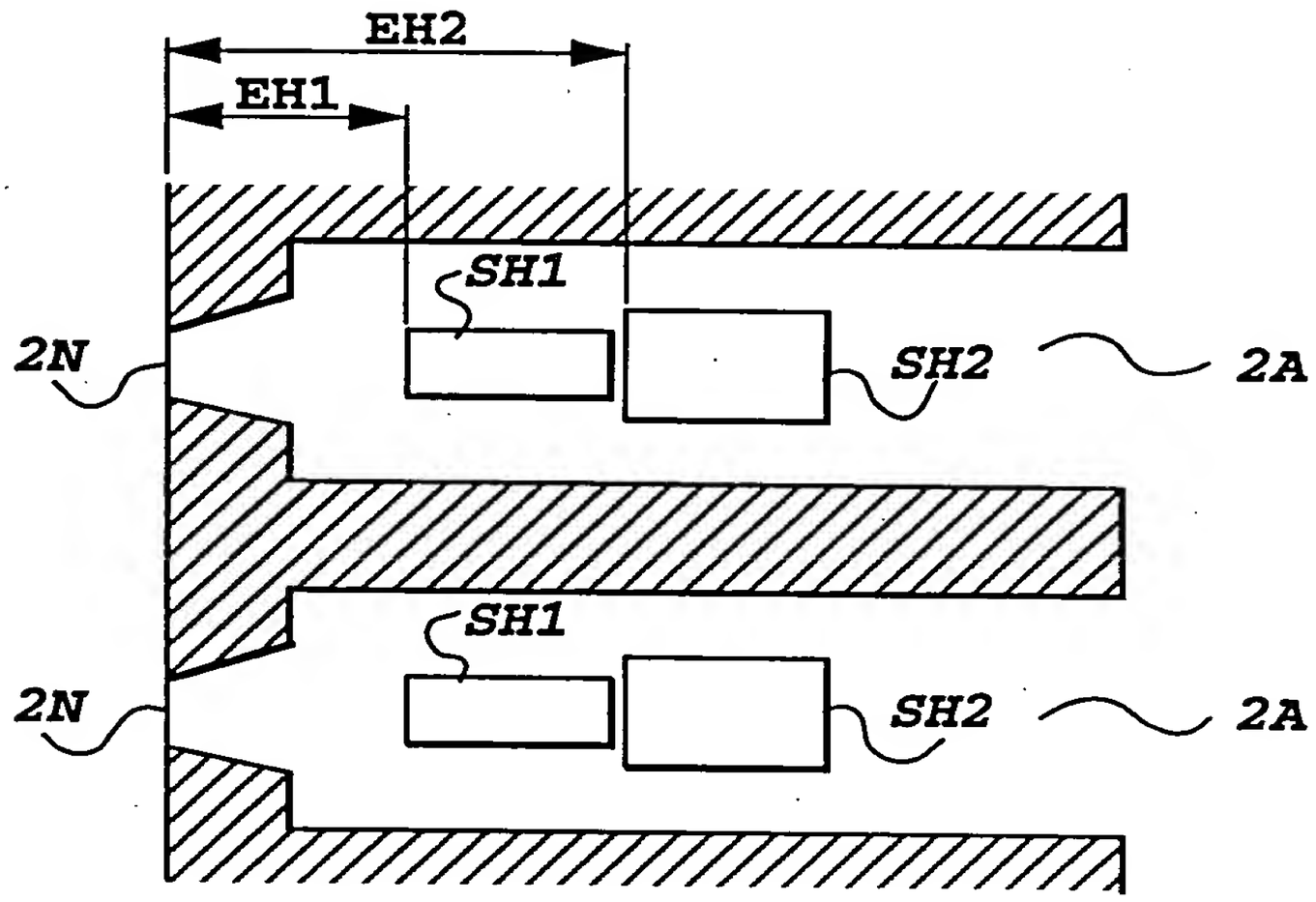

FIG. 18

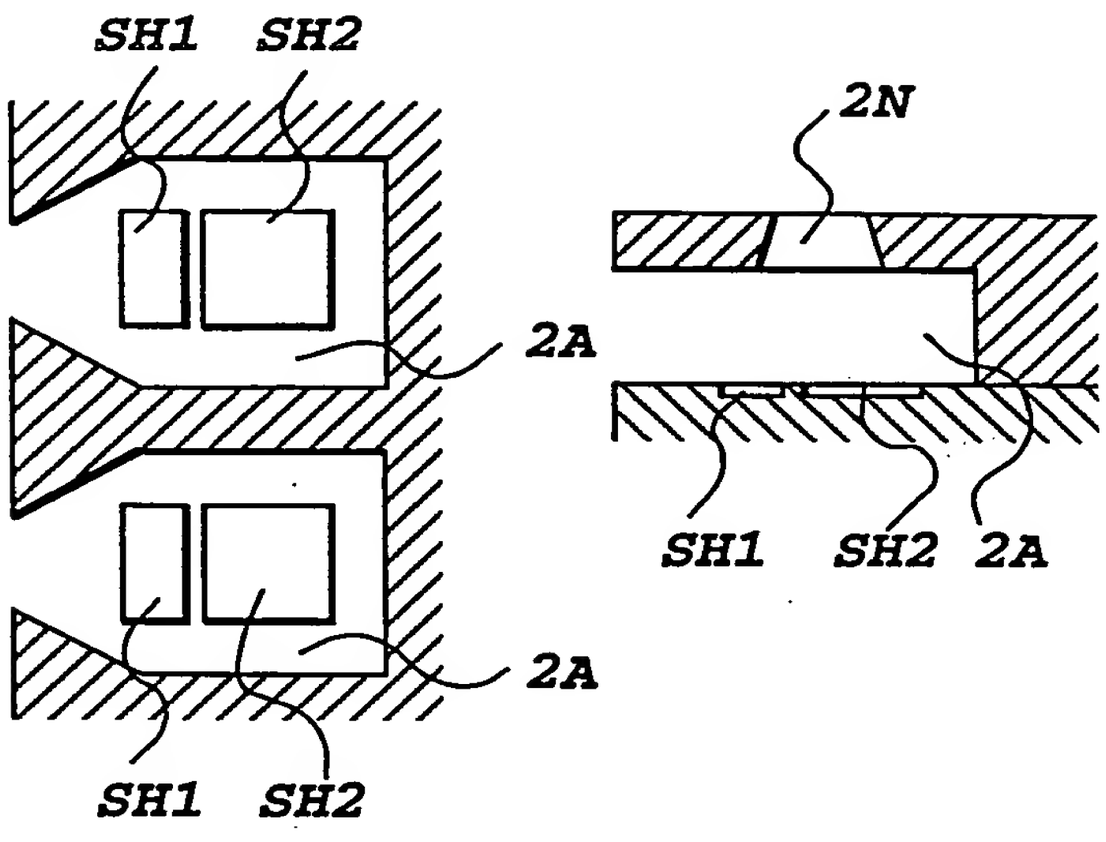

FIG. 19

[Document Name] Correction Data Ex Offico

[Document Corrected] Patent Application

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[DOCUMENT NAME] ABSTRACT

[Abstract]

[Object]

In an ink-jet apparatus using an ink-jet head having two heaters for one ink ejection opening, an ejection amount is stabilized with a relatively simple constitution.

[Construction]

In an ink-jet head in which an ejection amount can be varied by shifting applying timings of pulses to be applied to two heaters, a shifted period is varied according to a head temperature Th, thereby making the ejection amount constant even if the head temperature is varied.

[Figure Selected]

Fig. 8